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Forest Health Protection Report

Forest Insect and Disease Conditions in Alaska—2001



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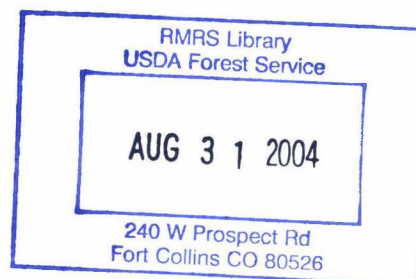
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Conditions in Brief

Aerial detection mapping is conducted annually to document the location and extent of active forest insect and disease damage. Each year these surveys cover approximately one-third of the forested land in Alaska. In 2001, inclement weather precluded flights into some areas of concern. Even so, over 22 million acres throughout Alaska were surveyed. This is the third year of overall decreased insect activity; although, areas not often affected by insect damage such as Sleetmute or Wood River-Tikchik State Park near Dillingham, did report insect damage. The most important diseases and declines in Alaska are characterized as chronic conditions and remain relatively unchanged.

Insects:

Spruce needle aphid defoliation occurred on approximately 20,200 acres in southeast Alaska from Long Island to Yakutat Bay. Most of the defoliation was located in the mainland beach fringe from the Stikine River to Excursion Inlet. The urban areas of Juneau and Wrangell were notably hard hit.

Approximately 51,000 acres of heavy spruce and hemlock **black-headed budworm** defoliation were reported in the Wood River-Tikchik State Park (31,000 acres) and Prince William Sound (20,000 acres). Black-headed budworm populations rise and fall rapidly (within 1–5 years) and appear to be controlled to a large degree by weather conditions.

Areas of active **spruce bark beetle** infestation increased in 2001 (plus 21 percent) over 2000 totals, from 86,038 acres in 2000 to 104,098 acres this year. Spruce stands around Lake Iliamna, Seldovia, and McCarthy continue to have the most spruce beetle activity. The infestations are in stands that have been previously undisturbed and/or are adjacent to ongoing infestations and provide a continual source of suitable breeding material for the beetle. Spruce beetle activity is expected to persist in these areas until weather conditions, lack of adequate host material, or other disturbances reduce their populations. Since 1997, the total area of beetle activity has declined precipitously. These previously infested areas (1,845,000 in the last six years), however, will remain at moderate to high risk for potential catastrophic wildfire due to the large volume of beetle-killed spruce timber, both standing-dead and down.

Spruce beetle activity in southeast Alaska was at a low of 950 acres from a high of 35,700 acres in 1996. About 600 acres of this activity was in the Chilkat drainage near the Canadian border. There were only 260 acres of activity in Glacier Bay National Park. No new acres were infested along the Taku River, near the Canadian border, nor on the Craig or Wrangell Ranger Districts.

No **spruce budworm** damage was mapped in previously mapped areas. The only activity noted was nearly 9,500 acres of light spruce budworm defoliation along the Teklanika River, while 16,000 acres of light to moderate defoliation was observed along the Tanana River.

Flooding was quite extensive in the interior along the Tanana, Chisana, and Nabesna Rivers; and the Yukon River between Koyukuk and Galena. Damage to trees and shrubs was not evident during the 2001 survey. However, we could see tree mortality or defoliation occurring throughout the flood plain next year as a result of the water caused stress.

Diseases:

The most important diseases and declines of Alaskan forests in 2001 were wood decay of live trees, root disease of white spruce, hemlock dwarf mistletoe, and yellow-cedar decline. Except for yellow-cedar decline, trees affected by these diseases are difficult to detect by aerial surveys. Nonetheless, all are chronic factors that significantly influence the commercial value of the timber resource and alter key ecological processes including forest structure, composition, and succession. Wildlife habitat is enhanced through the development of hollow tree cavities by heart rot fungi, and witches' brooms by hemlock dwarf mistletoe and broom rust fungi.

In southeast Alaska, approximately one-third of the gross volume of forests is defective due to **stem and butt rot fungi**. **Hemlock dwarf mistletoe** continues to cause growth loss, top-kill, and mortality in old-growth forests; its impact in managed stands depends on the abundance of large infected trees remaining on site after harvesting.

Approximately 500,000 acres of **yellow-cedar decline** have been mapped across an extensive portion of southeast Alaska. Snags of yellow-cedar accumulate on affected sites and forest composition is substantially altered as yellow-cedar trees die, giving way to other tree species. The wood in dead standing trees remains valuable long after tree death and salvage opportunities for this resource are now being recognized.

Spruce needle rust occurred at high levels in several areas of southeast Alaska for the third consecutive year. Cone and other foliar diseases of conifers were generally at low levels throughout Alaska in 2001. **Canker fungi** were at endemic levels, causing substantial, but unmeasured, damage to hardwood species in south-central and interior Alaska. Canker fungi on conifers, particularly on Sitka spruce and subalpine fir occurred at higher than normal levels and caused branch dieback in southeast Alaska.

In south-central and interior Alaska **tomentosus root rot** continues to cause growth loss and mortality of white spruce in all age classes. Various **stem and butt rot fungi** cause considerable defect in mature white spruce, paper birch and aspen stands. Saprophytic decay of spruce bark beetle-killed trees, primarily caused by the red belt fungus, continues to rapidly develop on and degrade dead spruce trees.

Other:

In the past several years, three specific introduced pests are causing concern in the Anchorage area. The **Sitka spruce weevil** (none were reported in 2001) and the **European black slug** may become established in Alaska if detection and eradication methods are not employed early. **Tufted vetch** has been observed as an aggressive plant invader along portions of the Seward highway in South Anchorage. It has been spotted along trails in Chugach State Park and on sites in the Hillside neighborhoods. In 2001, another, possibly introduced, insect caused heavy birch defoliation throughout Anchorage and the Mat-Su Valley. Although it has not been positively identified at this time, we suspect the defoliation to be caused by the larval form of a **sawfly**, which had not been identified in Alaska before 1996.

In localized areas of southeast Alaska, feeding by **porcupines** and **brown bears** continues to cause tree damage to several conifer species.

Table 1. 2001 forest insect and disease activity as detected during aerial surveys in Alaska by land ownership¹ and agent². All values are in acres.

Damage Agent	State & Private	National Forest	Other Federal	Native Corp.	Total 2001	Change From 2000
Alder Defoliation ³	366	759	62	0	1,186	-4,384
Aspen Defoliation ³	582		185	1,553	2,320	-4,647
Birch Defoliation ³	81		2,682	454	3,216	591
Black-Headed Budworm	27,617	12,889	1	10,217	50,724	50,724
Cedar Decline Faders ⁴	41	1,218	5	83	1,347	1,347
Cottonwood Defoliation ⁵	7,962	1,480	362	92	9,896	4,507
Hemlock Sawfly Defoliation	217	709	39	299	1,265	-3,843
<i>Ips</i> Engraver Beetle	15	8	19	8	49	-23,020
Larch Sawfly	514		16,588	719	17,821	-47,038
Large Aspen Tortix	5,862		337	930	7,129	1,553
Spruce Aphid	6,595	10,324	2,649	594	20,163	-13,156
Spruce Beetle	47,712	1,890	23,885	30,611	104,098	18,060
Spruce Budworm	25,499			20	25,520	-15,546
Spruce Needle Rust	174	1,606	7,609	1,255	10,644	8,353
Sub-Alpine Fir Beetle	51	3	2		56	56
Willow Defoliation ³	144	59	5,773	4,889	10,865	-25,137
Total Acres	123,432	30,943	60,198	51,725	266,299	-51,580

¹Ownership derived from 1999 version of Land Status GIS coverage, State of Alaska, DNR/Land records Information Section.

²Table entries do not include many of the most destructive diseases (e.g., wood decays and dwarf mistletoe) these losses are not detectable in aerial surveys.

³Significant contributors include leaf miners and leaf rollers for the respective host.

⁴Acres represent only spots where current faders were noticed. Cumulative cedar decline acres can be seen in Table 5.

⁵Significant contributors include cottonwood leaf beetle and leaf rollers.

Table 2. Acreage having active insect damage, by year, since 1996, and the cumulative area (in thousands of acres) affected for the last 6 years.

Damage Agent	1996 Total	1997 Total	1998 Total	1999 Total	2000 Total	2001 Total	Cumulative Totals ¹
Spruce beetle	1,133.0	563.7	316.8	253.3	86.0	105.0	1,845.4
Larch sawfly	606.9	267.6	461.8	159.3	64.9	17.8	1,494.1
Willow defoliation	50.1	3.5	123.1	180.4	36.0	10.9	376.8
Spruce budworm	235.9	38.4	87.8	0.7	41.1	25.5	349.7
Birch defoliation	3.2	271.9	0.5	2.8	2.6	3.2	284.3
Spruce aphid	0.5	0.5	46.4	4.3	37.6	20.2	105.8
Black-headed budworm	1.2	30.8	--	--	--	50.7	80.6
<i>Ips</i> Engravers	14.2	8.9	14.3	3.9	23.0	--	63.8
Large aspen tortrix	6.4	5.1	21.8	13.3	5.6	7.1	59.1
Cottonwood defoliation ²	5.4	3.0	6.6	5.6	5.4	9.9	35.1
Hemlock sawfly	8.3	6.6	3.9	--	5.1	1.3	25.3
Total thousands acres	2,065.1	1,200.0	1,083.0	623.6	307.3	251.6	4,720.0

¹The same stand can have active infestation for several years. The cumulative total is a union of all areas from 1996 through 2001.

²Tallies represent polygons coded to cottonwood defoliation and cottonwood leaf beetle (pest codes CWD CLB).

The Role Of Disturbance In Ecosystem Management

To the casual observer, forests may appear to be unchanging. In fact, most forests are in some stage of re-establishment after one or more disturbances. In Alaska, geological processes, climatic forces, insects, plant diseases, and the activities of animals and humans have shaped forests. To practice ecosystem management, we must understand how these cycles of disturbances have shaped and continue to influence various forest ecosystems.

Disturbances result in changes to ecosystem function. In forests, this often means the death or removal of trees. Disturbances caused by physical forces such as volcanoes, earthquakes, storms, droughts, and fire can affect the entire plant community, although some species may be more resistant to damage than others. Insects, plant diseases, animal and human activities are usually more selective, directly affecting one or several species.

Cycles of disturbance and recovery repeat over time and across landscapes. From evidence of past disturbances on a landscape, we can predict what type of disturbance is likely to occur in the future. Landscapes supporting large areas of single age stands indicate rare, but intense large-scale disturbances. Landscapes with a variety of age classes and species suggest more frequent smaller scale events. Usually, several types of disturbances at various scales of space, time, and intensity have influenced forest structure and composition on a given site. The role of disturbance in ecological processes is well illustrated in Alaska's two distinct forest ecosystem types and transition zones.

The temperate rain forests of southeast Alaska are dominated by western hemlock and Sitka spruce. Alaskan yellow-cedar, western red cedar, shore pine and mountain hemlock are also

important components. Trees on productive sites can attain great size due to abundant rainfall and moderate temperatures. Wind is the major disturbance agent in southeast. Degree of impact and scale depends on stand composition, structure, age and vigor and as well as wind speed, direction, duration and topographic effects on wind flow. The forest type most susceptible to wind throw is mature spruce or hemlock on productive, wind-exposed sites. The large, top-heavy canopies act as sails and uprooting is common, resulting in soil churning, which expedites nutrient cycling and increases soil permeability. Even-aged forests develop following large-scale catastrophic wind events. Old-growth forest structure develops in landscapes protected from prevailing winds. In these areas, small gap-forming events dominate. Trees are long-lived, but become heavily infected with heart-rot fungi, hemlock dwarf mistletoe, and root rot fungi as they age. Weakened trees commonly break under the stress of gravity and snow loading. Canopy gaps generated this way do not often result in exposed mineral soil.

The boreal forests of interior Alaska are comprised of white spruce, black spruce, birch, aspen and poplar. The climate is characterized by long, cold winters, short, hot summers, and low precipitation. Cold soils and permafrost limit nutrient cycling and root

growth. Topographic features strongly influence microsite conditions; north-facing slopes have wet, cold soils, whereas south-facing slopes are warm and well drained during the growing season. Soils are usually free from permafrost along river drainages, where flooding is common. Areas more distant from rivers are usually underlain by permafrost and are poorly drained. Fire is the major large-scale dis-



Figure 1. Wind disturbance is a common precursor to other forms of disturbance such as bark beetles, fire, and landslides.

turbance agent; lightening strikes are very common. All tree species are susceptible to damage by fire, and all are adapted, to various degrees, to regeneration following fire. Fire impacts go beyond removal of vegetation; depending on the intensity and duration of a fire, soil may be warmed, upper layers of permafrost may thaw, and nutrient cycling may accelerate. Patterns of forest type development across the landscape are defined by the basic silvics of the species involved. Hardwoods are seral pioneers, resprouting from roots or stumps. White spruce stands are usually found on better-drained soils, along flood plains, river terraces, and on slopes with southern exposure. Black spruce and tamarack occur in areas of poor drainage, on north-facing slopes, or on upland slopes more distant from rivers where permafrost is common.

South-central Alaska is a transition zone between the coastal marine climate of southeast and the continental climate of the interior. These forest communities are more similar to those in the interior, except where Sitka spruce and white spruce ranges overlap and the Lutz spruce hybrid is common. Fire has been a factor in the forest landscape patterns we see today. These fires, however, were mostly the result of human activity; lightning strikes are uncommon in the Cook Inlet area. Major disturbances affecting these forests in the past century have been human activity and spruce beetle caused mortality. Earthquakes, volcanic eruptions, and flooding following storm events have also left significant signatures on the landscape.

Disturbances play an important role in shaping forest composition, structure, and development. With knowledge of disturbance regimes, managers can understand key processes driving forest dynamics and gain insight into the resiliency (the ability to recover) and resistance (the ability to withstand change) of forests to future disturbance. As we improve our understanding of the complexities of these relationships, we are better able to anticipate and respond to natural disturbances and mimic the desirable effects with management activ-

ities. Ecological classification is one tool available to help us understand disturbance patterns.

Several useful systems of classification have been developed for Alaska's ecosystems and vegetation. Efforts to refine and standardize these classifications across all ownerships produced a unified map in 2000. Field and resource specialists representing a variety of organizations, including representatives from Canada, came together to evaluate two existing maps (Gallant et al. 1995 and Nowacki and Brock 1995) along with additional resource information. Line placement was refined using the best available data. Delineation criteria ultimately included climate, physiography, vegetation, and glaciation.

In Alaska, three distinct climatic-vegetation regimes exist representing polar, boreal, and maritime. These regimes cover broad areas and grade from one to another across the state (see map on following page). To accommodate this spatial arrangement, ecoregion groups were arranged in a triangular manner reflecting the major regimes and gradations between them (see the following figure). Through this projection (a triarchy), the natural associations among ecoregion groups are displayed as they occur on the land without loss of information (i.e., retains the spatial interrelations of the groups). An ecoregion map can be seen on the following page and ecoregion descriptions are included in Appendix D.

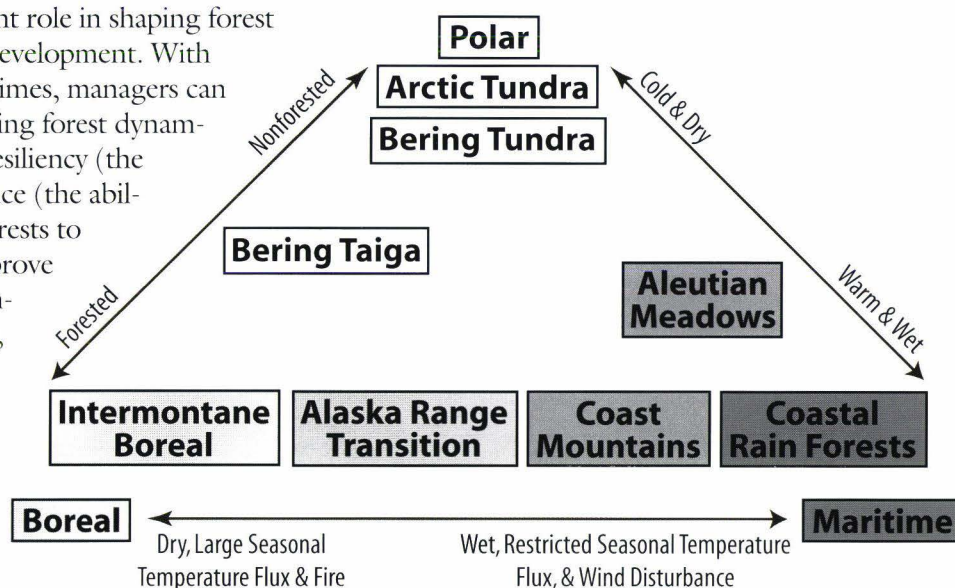
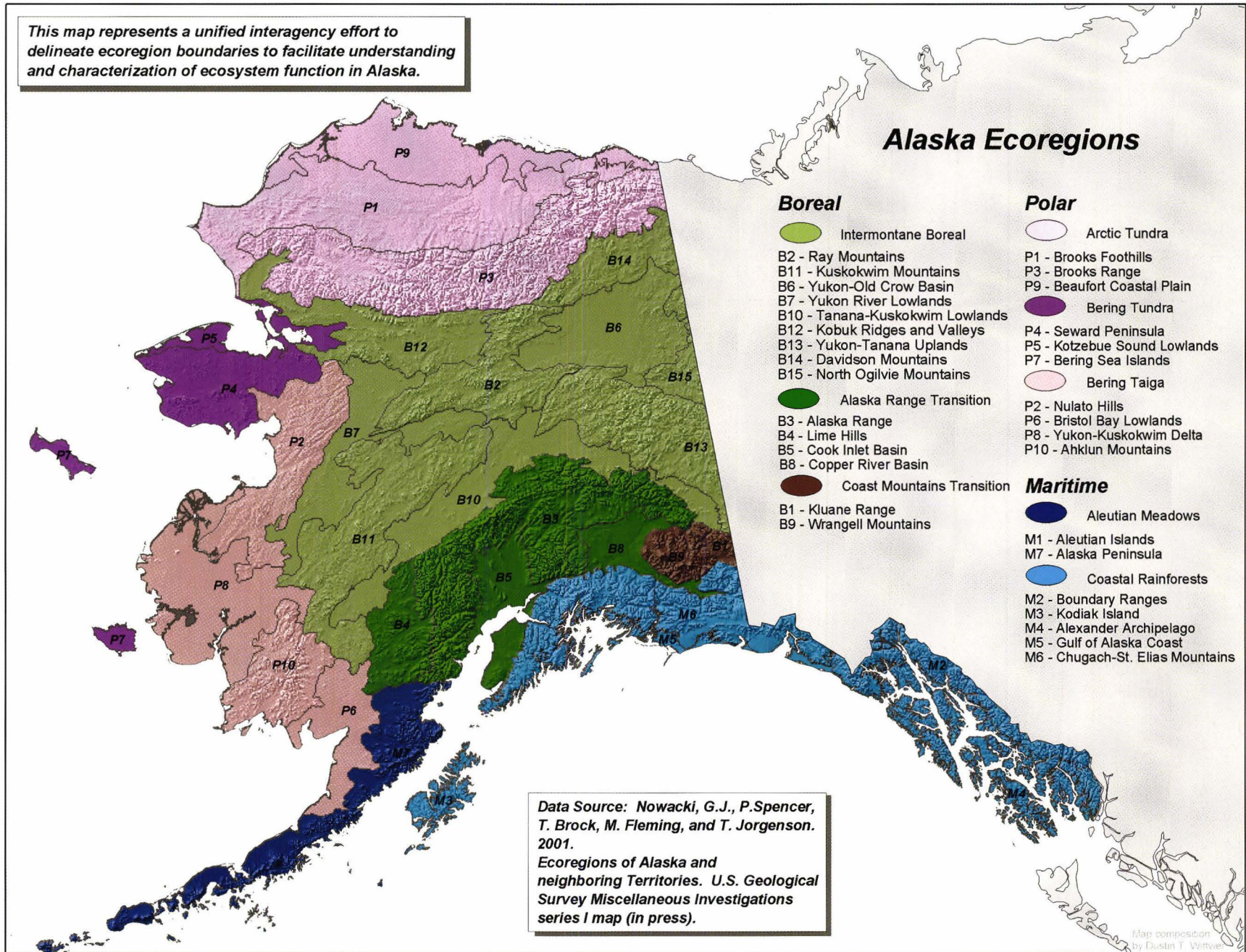


Figure 2. This triarchy illustrates the major regimes and gradations between the Alaska ecoregions.

This map represents a unified interagency effort to delineate ecoregion boundaries to facilitate understanding and characterization of ecosystem function in Alaska.



Bark Beetles

Bark Beetles as Agents of Disturbance

Insects are active and significant components of Alaska's ecosystems. Arctic-boreal insects are characterized by having few species and large population numbers. Boreal insects are opportunistic in their behavior. They respond quickly to changes in climate and the availability of food and breeding material. Spruce beetles, for example, are one of the most important disturbance agents in mature white spruce stands in south-central and interior Alaska. The spruce beetle responds quickly to large-scale blowdown, fire-scorched trees, and spruce injured by flooding. Large numbers of beetles can be produced in such breeding material, leading to potential outbreaks.

A variety of changes occur to forest resources when many trees are killed. In the long run these changes are biological or ecological in nature. There are also socioeconomic consequences in the short term that can be viewed as either positive or negative, depending on the forest resource in question. Some of the impacts associated with spruce beetle infestations include, but are not limited to:

- ◆ **Loss of merchantable value of killed trees:** The value of spruce as saw timber is reduced within three years of attack in south-central Alaska due to weather checking and sap-rots. The value of beetle-killed trees as house logs, chips, or firewood continues for many years if the tree remains standing.
- ◆ **Long-term stand conversion:** The best regeneration of white and Lutz spruce and birch occurs on a seedbed of bare mineral soil with some organic material. Site disturbances such as fire, windthrow, flooding, or ground scarification provide excellent sites for germination and establishment of seedlings if there is an adequate seed source. However, on some sites in south-central Alaska, grass and other competing vegetation quickly invade the sites where spruce beetles have "opened up" the canopy. This delays re-establishment of tree species. Regeneration requirements for Sitka spruce are less exacting; regeneration is thus, less problematic.
- ◆ **Impacts to wildlife habitat:** Wildlife populations, which depend on live, mature spruce stands for

habitat requirements may decline. We expect to see decreases in red squirrels, spruce grouse, Townsend Warblers, Ruby-crowned kinglets, and possibly Marbled Murrelet populations. On the other hand, wildlife species (moose, small mammals and their predators, etc.) that benefit from early successional vegetation such as willow and aspen may increase as stand composition changes.

- ◆ **Impacts to scenic quality:** Scenic beauty is an important forest resource. It has been demonstrated that there is a significant decline in public perception of scenic quality where spruce beetle impacted stands adjoin corridors such as National Scenic Byways. Maintaining or enhancing scenic quality necessitates minimizing impacts from spruce beetle infestations. Surveys have also shown that the public is evenly divided as to whether spruce beetle outbreaks damage scenic quality in backcountry areas.
- ◆ **Fire hazard:** There is concern that fire hazard in spruce beetle impacted stands will increase over time. After a spruce beetle outbreak, grass or other fine vegetation increases; fire spreads rapidly through these vegetation types. As the dead trees break or blow down (5–10 years after an outbreak), large woody debris begins to accumulate on the forest floor. This material (boles) is the largest component of the fuels complex. Heavy fuels do not readily ignite, but once ignited they burn at higher temperatures for a longer period. The combination of fine, flashy fuels and abundant large woody debris results in a dangerous fire behavior situation. Rate of fire spread may increase as well as burn intensity. Observations from recent fires on the Kenai Peninsula have shown an increase in crown fires. This fire behavior is caused by fire traveling up the dead spruce trees and spotting into the crowns of adjacent beetle killed trees.
- ◆ **Impact to fisheries:** If salmon spawning streams are bordered by large diameter spruce and these trees are subsequently killed by spruce beetles, there is a concern as to the future availability of large woody debris in the streams. Large woody debris in spawning streams is a necessary component for spawning habitat integrity.

- ◆ **Impact to watersheds:** Intense bark beetle outbreaks can kill large amounts of forest vegetation. The “removal” of significant portions of the forest will impact to some degree the dynamics of stream flow, timing of peak flow, etc. There have been no hydrologic studies in Alaska quantifying or qualifying impacts associated with spruce beetle outbreaks. Impact studies, however, have been done elsewhere. In Idaho watersheds impacted by the Mountain Pine Beetle, there was a 15 percent increase in annual water yield, a 2–3 week advance in snowmelt, and a 10–15 percent increase in low flows.

There are a variety of techniques that can be used to prevent, mitigate, or reduce impacts associated with spruce beetle infestations. However, before pest management options can be developed, the resource objective(s) for a particular stand, watershed, landscape, etc. must be determined. The forest manager must evaluate the resource values and economics of management actions for each stand in light of management objectives. The beetle population level must also be considered because population levels will determine the priority of management actions and the type of strategy to be invoked. The key to forest ecosystem management is to manage vegetation patterns in order to maintain species diversity, both plant and animal, while providing for a multitude of resources such as recreation, fisheries, wildlife, and the pro-

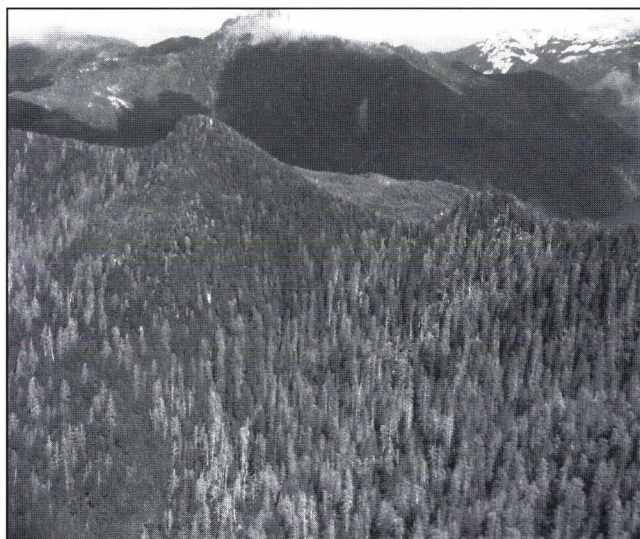


Figure 3. Gray trees were killed by spruce beetle.

duction of wood fiber. Properly applied silvicultural practices as well as fire management in south-central and interior Alaska can maintain the forest diversity needed to provide the range of products and amenities available in the natural forest for now and in the future.

Spruce Beetle

Dendroctonus rufipennis Kirby

Total area of active infestations by spruce bark beetles increased in 2001 (plus 21 percent) over 2000 totals, from 86,038 acres in 2000 to 104,098 acres this year. Since 1997, there had been an annual decline in number of acres of active infestation attributable to the spruce beetle. In 1997, 1998, and again in 2000 total area of beetle activity declined precipitously (approximately 50 percent) from previous year totals. Overall, acres of beetle activity fell from 1.1 million in 1996 to 86,000 acres in 2000 (minus 92 percent). As reported in earlier insect and disease conditions reports, spruce beetle infestations remain active in many areas of the State. These stands have been previously undisturbed and/or are adjacent to ongoing infestations and provide a continual source of suitable breeding material for the beetle. Spruce beetle activity is expected to persist in these areas until weather conditions, lack of adequate host material, or other disturbances reduce their populations. Vast areas of the state have been rendered unsuitable for further, large-scale beetle activity due to changes in stand structure, loss of host material, or forest-type conversion. Within these areas, beetle populations, for the most part, have been reduced to endemic levels. These same areas, however, will remain at moderate to high risk for potential catastrophic wildfire due to the large volume of beetle-killed spruce timber, both standing-dead or on the ground. Much of the Copper River Valley, Kenai Peninsula, and the west side of Cook Inlet fall into this category.

Significant, active infestations continue in the Iliamna Lake, Seldovia, McCarthy, and Anchorage areas. Lesser (in terms of acres impacted) activity occurs along the Kuskokwim River, on the Kenai Peninsula near Tazlina Lake, and in the Wood River–Tikchik Lake State Park.

Overall on the Kenai Peninsula in 2001, including the Chugach National Forest, the south side of Kachemak Bay and the remainder of the Peninsula,

total acres of active beetle activity fell from 49,200 acres in 2000 to 27,051 acres in 2001, a 45 percent decline. Approximately 1,860 acres of spruce beetle activity on the Chugach National Forest lands were mapped in 2001. The three small areas of beetle activity observed in 2001 are: 1) 180 acres of light (less than 10 trees per acre) spruce beetle activity at Pass Creek between the Hope “Y” and Lower Summit Lake; 2) 52 acres of light activity along Quartz Creek near Jerome Lake; 3) 72 acres of light activity along Crescent Creek. Approximately 1,000 of the 1,800 acres of spruce beetle activity noted on the Chugach National Forest this year are located 40 miles east of Cordova at the Johnson Glacier. This previously unreported area has no current activity but there is a considerable volume of dead standing timber. As this area is relatively inaccessible, it is uncertain whether the spruce beetle caused this damage. No other large, contiguous areas of beetle activity were observed and it appears populations have fallen to endemic levels. Activity is widely scattered and confined to small groups of trees within stands previously infested primarily in the Resurrection Creek, Sixmile Creek, and Trail River valleys. On the remaining Kenai Peninsula portion of the National Forest, approximately 250 attacked trees are scattered over 560 acres. No previously unattacked areas were impacted.

One of the most active areas of spruce beetle in Alaska in 2001 occurs on the south side of Kachemak Bay, though even here, activity has declined significantly over 2000 levels. Mapped acres of activity fell from 18,900 acres in 2000 to 10,280 acres in 2001 (minus 46 percent). This also is one of the few areas of the State where beetle activity is characterized as medium (11–19 trees per acre) to heavy (greater than



Figure 4. Spruce beetle adult.

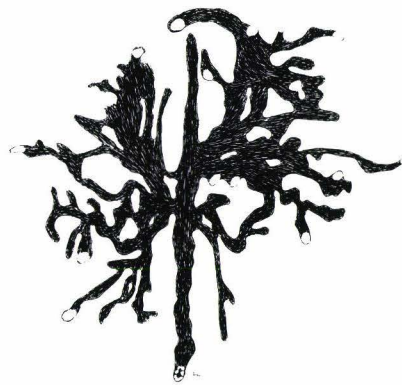


Figure 5. Typical pattern of spruce bark beetle galleries.

20 trees per acre) in intensity. The majority of the concentrated activity is occurring between Seldovia and Kasitna Bay and from Jakalof Bay to China Poot Bay. Though there are some discrete areas of activity between 500–2,000 acres, much of the activity is confined to “spots” of just several acres with 5–20 infested trees per spot. Yukon Island was observed to have 358 acres of heavy activity. The small infestation in English Bay is characterized as medium in intensity and occurring in discrete spots of less than ten acres containing fewer than 20 trees per spot. There remains adequate host material in this area and there is room yet for expansion of beetle activity between Seldovia and English Bay provided conditions are suitable for brood production.

On the Kenai Peninsula, from Point Possession to Homer, spruce beetle activity fell from 30,300 acres in 2000, to 15,823 acres in 2001 (minus 48 percent). With the exception of a 247-acre patch of medium activity near Homer, all remaining activity was placed in the light category. The most active area (8,274 acres) occurred along a narrow, coastal strip of land extending from Kasilof to the East Forelands. Though most of this activity is rather widely scattered, one larger block (3,434 acres) of light activity occurs just west of Kasilof, along the Cook Inlet shore. Light activity (2,873 acres) was reported along the Killey River just south of Skilak Lake, while 1,136 acres of light activity were observed adjacent to the Captain Cook State Recreation Area. These areas account for the majority of spruce beetle activity mapped on the Kenai Peninsula exclusive of the Chugach National Forest. The balance of activity is occurring in patches of less than 100 acres. As in all mapped areas of spruce beetle activity statewide this year; current impact on the Kenai Peninsula is confined to areas that have experienced spruce beetle activity in the recent past.

Following a significant drop in spruce beetle activity in the Iliamna Lake region in 2000 over 1999 levels, activity has risen again to 1999 levels. This region represents the only area in the State that has experienced a significant increase in activity. Spruce beetle activity rose from 2,250 acres in 2000 to 24,781 acres in 2001 (plus 1,001 percent). Approximately 30 percent of the activity is considered light, 45 percent medium, and 24 percent heavy. The majority of the heavy activity is reported around Old Iliamna Village (524 acres), Kakhonak Bay (1,141 acres), and from Pile Bay to Kakhonak Bay along the lake-shore (3,853 acres). Iliamna River–Pile Bay area reported 13,467 acres of activity of all classes with the majority of activity classified as light. The Pedro Bay–Porcupine Island area accounted for 3,858 acres of activity of light and medium activity of which 99 percent was considered light. With the exception of the Pedro Bay area, the majority of the activity mapped was confined to areas previously infested. The Iliamna Lake infestation should begin to decline again in 2002 due, primarily, to the depletion of suitable brood material. This infestation was first observed in 1992, and since that time, the majority of the susceptible spruce has been killed. Little material remains to carry this infestation for much longer. Spotty activity is expected to continue for the next several years. Concern remains, however, that this infestation may move up to the Lake Clark area where vast areas of susceptible spruce remain to be exploited by the beetle. At this point, it is not clear why the beetle has not entered this region. Though the Lake Clark Pass area to the east of Lake Clark and the Iliamna Lake area just to the south have been heavily

impacted, the beetle has not yet moved into the Lake Clark area.

Acreage figures for spruce beetle activity in the Susitna River Valley have fallen slightly from 2000 levels. In 2001, 2,985 acres of beetle activity were mapped as compared to 3,700 acres in 2000 (minus 19 percent). The activity was confined to a narrow strip of land along Knik Arm between Goose Bay and Point McKenzie and was considered light in intensity. No further activity was noted in this region.

In the Matanuska River valley, 16,163 acres of very light beetle activity were reported between Sutton and the Chickaloon River Valley. All activity is confined to areas heavily impacted in prior years and most likely represents beetles working through stands and infesting the remaining susceptible material. Little future activity is expected in these stands.

Moving into interior Alaska, 1,999 acres of light beetle activity was noted along the Nelchina River near the face of the Nelchina Glacier, and between Twin Lakes and Tazlina Lake where 755 acres of light activity were mapped.

Spruce beetle activity continues in the McCarthy area where the only instance of beetles moving into a new area was recorded this year; 6,692 acres of new, heavy activity was reported in the McCarthy Creek drainage.

In the Moose Lake–Crystalline Hills area, 831 acres of light activity were mapped. 108 acres of continuing (light) activity in the vicinity of Kennicott Glacier were mapped. Other activity in the area was: 144 acres of medium activity around May Creek; 2,461 acres of light activity around Castle Bluffs; 376 acres of light activity around Towhead Mountain. The large infestation in the Hanagita River drainage continues, but at a less intense level. 5,058 acres of light activity were mapped, and were confined within the limits of prior activity. Activity in this drainage is expected to decline in 2002, as the majority of host material has been depleted.

Only two other areas of spruce beetle activity in interior Alaska bear mention. Near Sleetmute, on the Kuskokwim River, 3,091 acres of light beetle activity were mapped. Reports from local residents imply that this activity is a result of local firewood cutting. Further north along the Kuskokwim River, between Devil's Elbow and McGrath, 2,348 acres of scattered, light beetle infestation activity were observed. Much

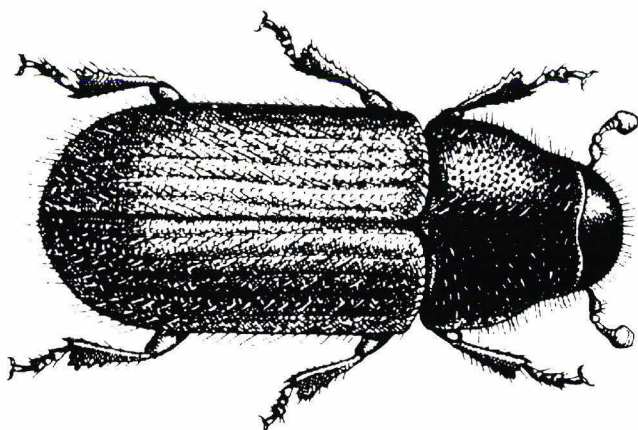
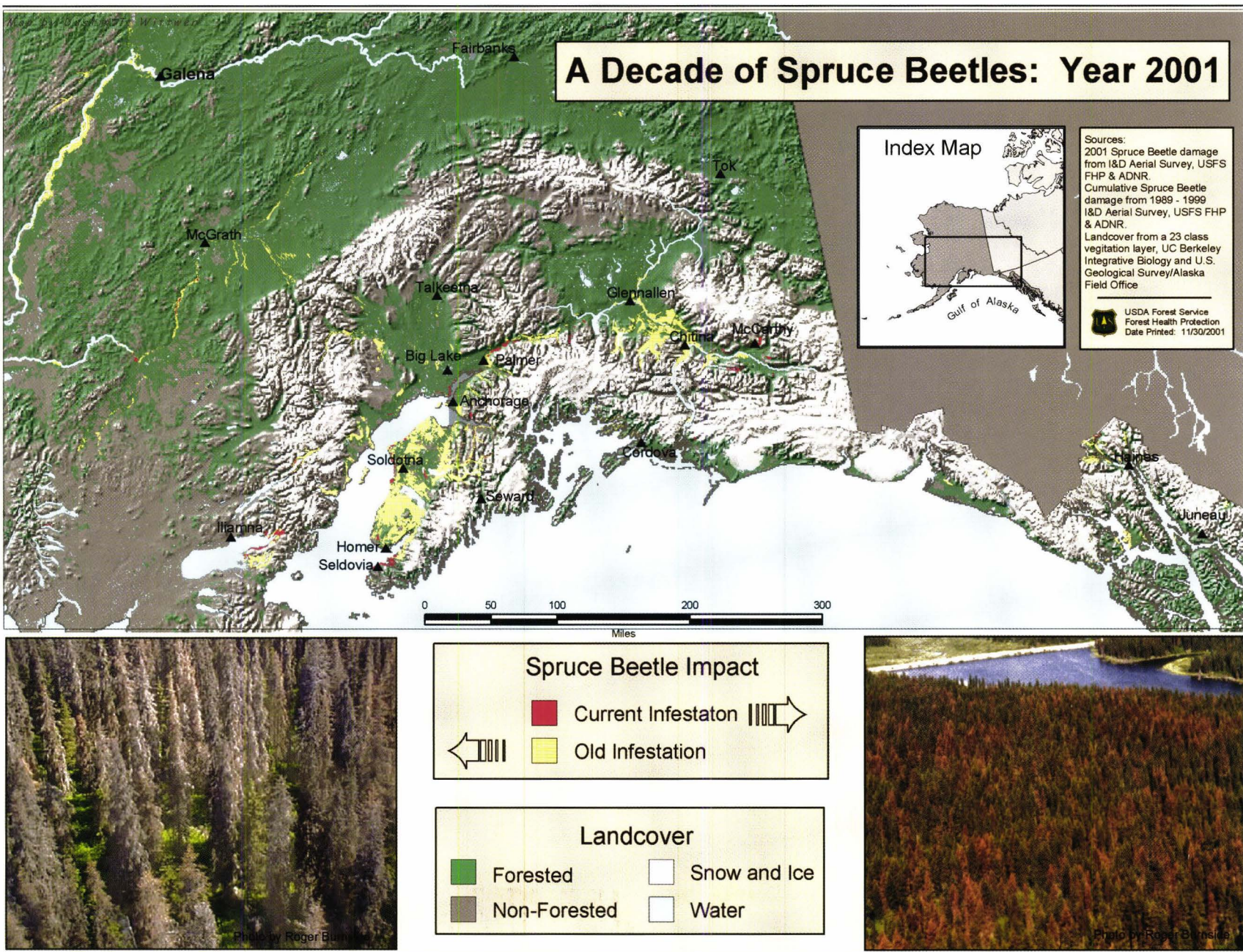
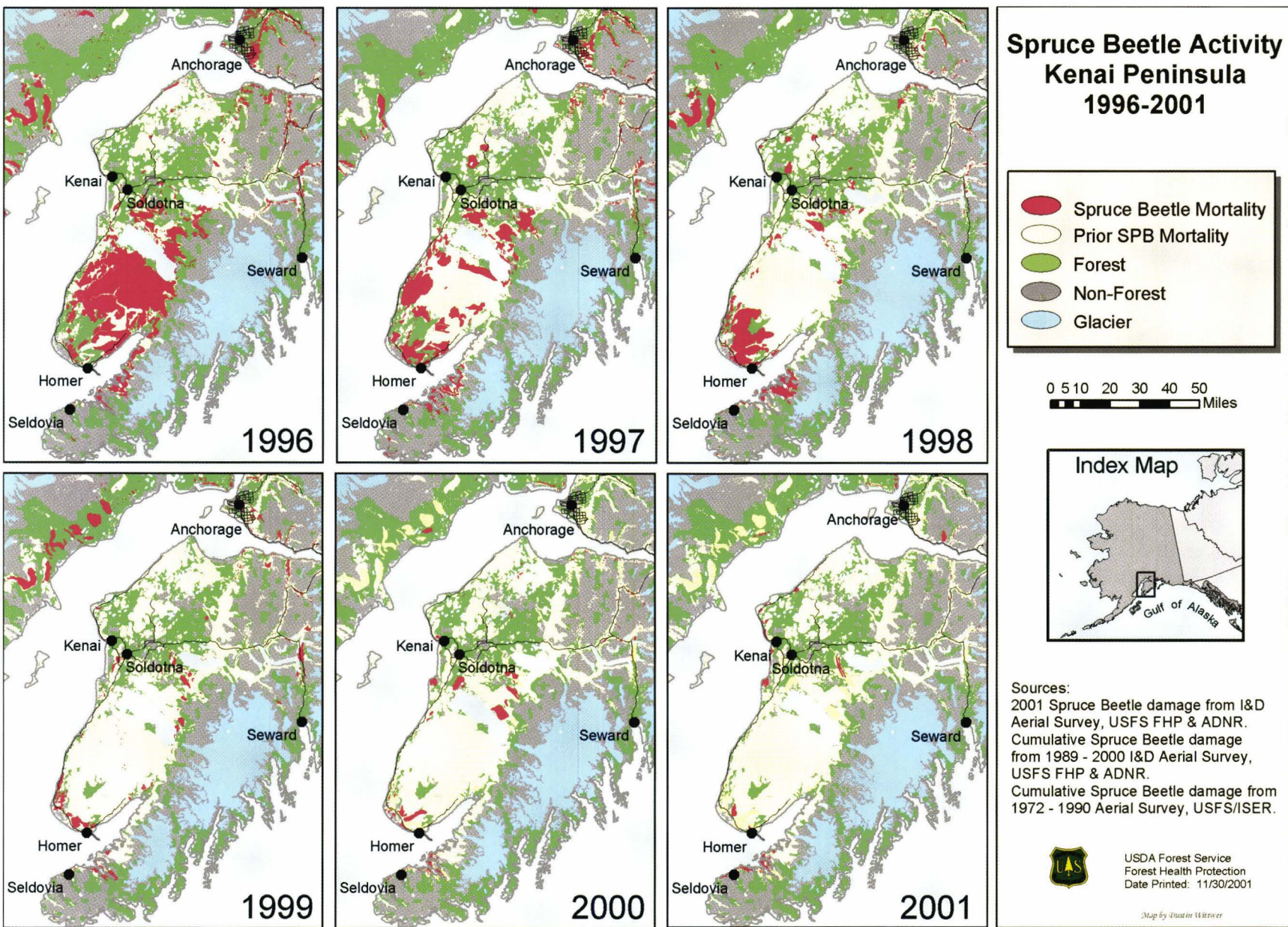


Figure 6. Spruce bark beetle.

Map 2. A Decade of Spruce Beetles: Year 2001.



Map 3. Kenai Sequential, 1996-2001, Spruce Beetle Map.



of this activity is associated with small-scale logging operations in the vicinity.

Finally, the beetle infestation that has impacted the Anchorage Bowl and surrounding communities for the past 11 years appears to have collapsed. No new activity was reported in the Anchorage Bowl, or in the nearby watersheds of Ship Creek, Eagle River, Peters Creek or the Eklutna River. Along Turnagain Arm, one large area of light activity, 2,800 acres, was noted within the Indian Creek drainage. Scattered, light activity was noted in the Bird Creek drainage, characterized by small spots of 10–30 infested trees. Depending on climatic conditions and/or disturbance factors, these small, discreet infestations have the potential to intensify; however, spread beyond their natural boundaries is unlikely due to lack of host material.

Spruce beetle activity in southeast Alaska's Sitka spruce forests was only 950 acres. Current spruce beetle activity occurred mostly in the upper Chilkat River drainage and on the coastal side of Glacier Bay National Park and Preserve. None was found in the traditionally infested areas of the Taku River and Stikine delta.

In summary, the spruce beetle epidemic that has taken such a heavy toll on south-central Alaska forests for more than 20 years appears to be over. During that time nearly 4 million acres were substantially affected with many areas having nearly all potential host trees killed. Currently, in most areas, beetle numbers have been reduced to endemic levels (less than 1 tree per acre). Continuing activity can be expected in some previously impacted areas and there remains the potential for expansion to new areas depending on climate and disturbance factors. Large areas of susceptible spruce stands remain, particularly along the Kuskokwim and Yukon Rivers and in the Lake Clark area.

Bark Beetles in Subalpine Fir

An unidentified bark beetle killed 56 acres of subalpine fir in the Skagway River drainage. There is a good possibility that this beetle could be the western balsam bark beetle, *Dryocoetes confusus*. A ground survey revealed that some trees were dead for more than one year. There were less than one-third of the attacked and killed trees newly attacked. This indicates that the outbreak is short-lived and almost over.

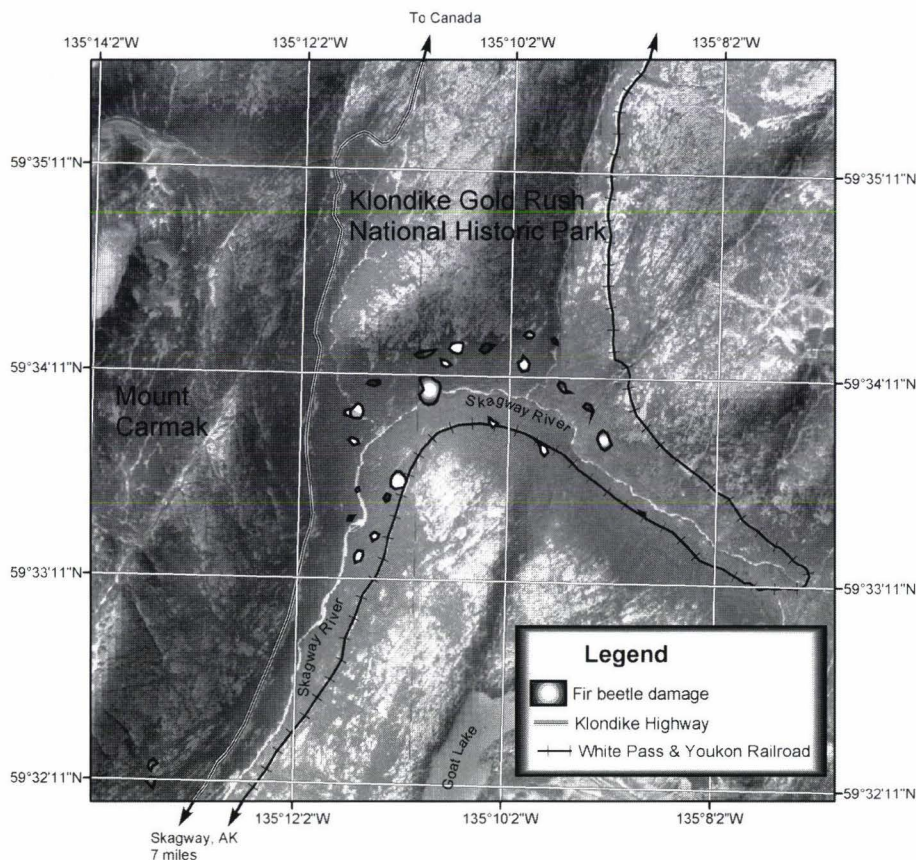


Figure 7. Subalpine fir bark beetle outbreak.

Engravers

Ips perturbatus Eichh.

Engraver activity decreased from 23,000 acres detected in 2000 to less than 30 acres detected in 2001. The scattered *Ips*-caused tree mortality was concentrated in interior Alaska where *Ips* infestations occur primarily along river flood plains and areas disturbed by past erosion, spruce top breakage (e.g., snow loading), harvest, or wind. Most *Ips* activity is very localized and can be distinguished from spruce beetle damage by dying and reddening upper crowns in mature spruce. *Ips* are often associated with spruce beetle in the same general areas, however, *Ips* typically respond faster than spruce beetle in these areas since they are a more aggressive bark beetle in keying in to host stresses and nutrient changes brought on by these various disturbances. Increased *Ips* activity may occur next year as a result of the extensive flooding along the Nabesna, Chisana, and Nanana Rivers.



Figure 8. Engraver beetles are distinguished by spines on the posterior.

Defoliators

Defoliators as Agents of Disturbance

Defoliator insects eat the leaves or needles of forest trees. Insects that defoliate are found throughout Alaska and on all tree types. While bark beetles are the more significant disturbance insects to trees in boreal Alaska, defoliator insects tend to be more significant in maritime ecosystems. If complete defoliation of a conifer occurs before midsummer, the trees will not have formed buds for the following year and the tree could be killed. Conifers dominate the maritime system of Prince William Sound and southeast Alaska.

In a defoliator outbreak where insect populations are at epidemic levels, vast acreages can be affected. During an outbreak nearly every tree in a stand can be affected to varying degrees. This defoliation often results in a variety of biological and ecological impacts, but there are socioeconomic impacts as well. Some of the impacts associated with a defoliator infestation include, but are not limited to:

- ♦ **Impacts to wildlife habitat:** Wildlife may be positively or negatively affected by defoliator outbreaks. Larvae are a necessary food source to fledge chicks but bird habitat may be negatively affected by the decrease in cover. Conversely, predatory birds may benefit from the cover change. The added light to the forest floor will result in an increased ground cover of herbaceous plants, benefiting browse animals such as deer.
- ♦ **Impacts to aquatic systems:** Aquatic systems may be also be positively or negatively affected. Nutrient cycling is accelerated as foliage and insect waste enters the aquatic system. Larvae, themselves, drop into streams and can serve as a food source for fish. In addition, the loss of overstory cover can increase sunlight exposure to the stream affecting the aquatic system.
- ♦ **Economic concerns:** Economically, heavy defoliation will decrease the growth rate of trees resulting in longer periods of time to reach merchantable size. In addition to growth loss, repeated and or heavy defoliation events can cause top kill and in some cases tree death.

♦ **Aesthetics and Recreation:** The visual impact of a stand in the midst of an outbreak can be quite alarming when the entire hillside appears brown or red. However, the alarming look is short term and once the dead needles drop to the ground, scenic quality returns closer to “normal.” Large number of larvae can be a nuisance in picnic grounds and campgrounds. Defoliated stands also lose their attractiveness for recreation. If top kill or tree death should occur hazards trees may result in recreational areas.

Defoliator outbreaks tend to be cyclic and closely tied to climatic conditions. For defoliators the synchronization of larval emergence and tree bud break is closely related to defoliator population increases. Temperature during larval development affects survival, pupation, number of viable adults, and egg laying success for many common defoliators. The better the synchronization of insect and host throughout larval development the more certain that an epidemic will occur. Host-insect synchronization and favorable climate for insect development has resulted in a tremendous acreage of defoliated western hemlock in the early 1950s. Only ten percent of heavily defoliated trees were top killed and only a small number of those died.

Suppression efforts of insect populations are usually limited to small scale urban settings or high value recreational sites. Suppression techniques vary depending on defoliator agent. Forest ecological processes include periodic insect defoliation. Land managers must consider the predicted duration and extent of the event and predicted resource effects when considering suppression actions.

Southeast Alaska Defoliator Plots

Thirty plots, across Southeast Alaska, were visited during the 2001 aerial survey. Larval counts from these plots can be used as a predictive tool for defoliator outbreaks. Fourteen plots had at least one arthropod from the ten trees sampled on each plot. Fifty-five of the 283 trees sampled had arthropods. Most of them were hemlock sawflies and they were on 27 trees. The plot with the most hemlock sawflies

is located on Thorne Island, Prince of Wales Island. Most of the hemlock sawflies were samples from trees on plots south of Fredrick Sound. Black-headed budworm were found on only two of the 55 trees. Given the low sample numbers, we expect overall defoliator activity on hemlocks in southeast Alaska to be at endemic levels for 2002.



Figure 9. Progression of top-kill following repeated budworm defoliation.

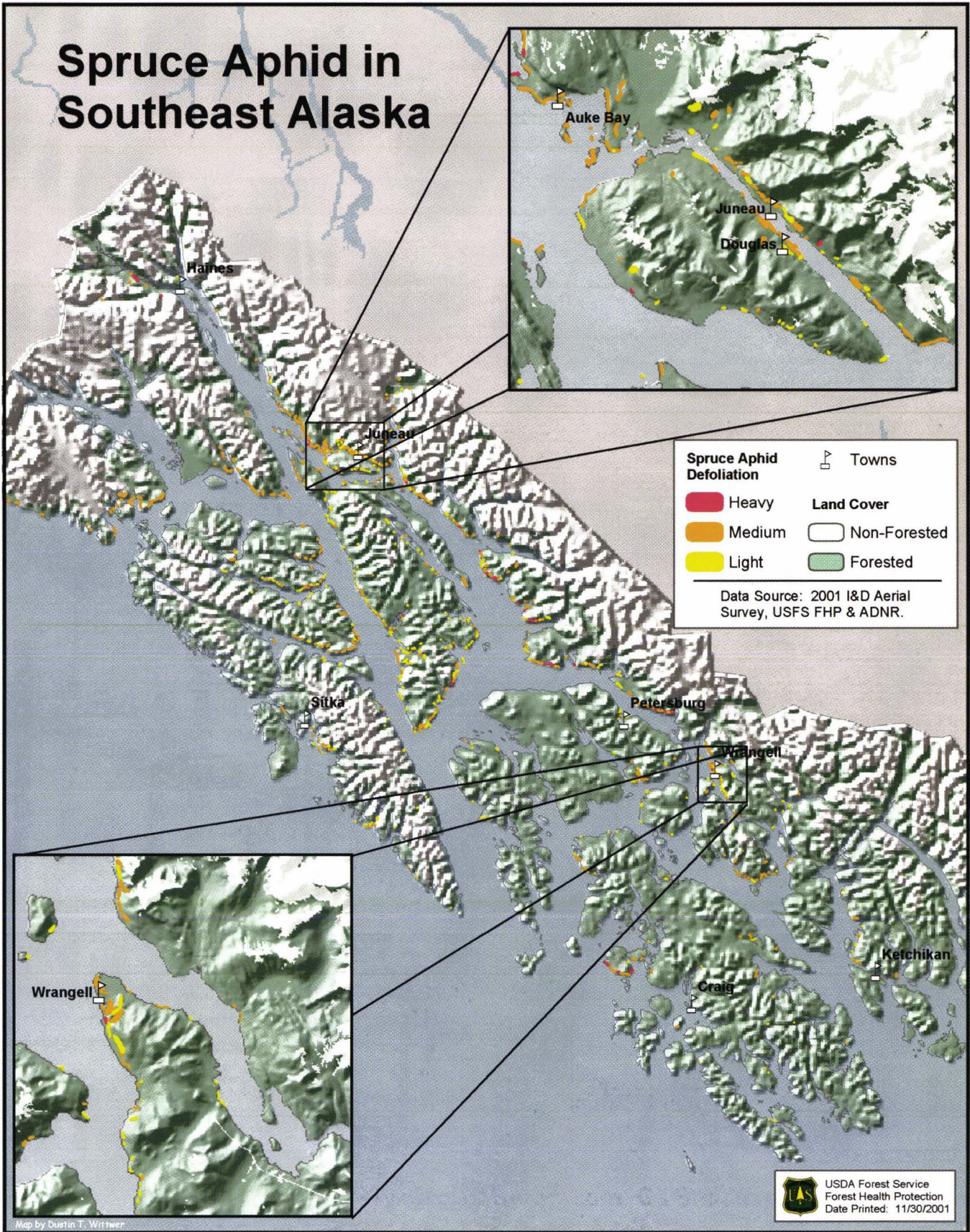
Spruce Aphid

***Elatobium abietinum* Walker**

Spruce aphids feed on older needles of Sitka spruce, often causing significant amounts of needle drop (defoliation). Defoliation by aphids cause reduced tree growth and can predispose the host to other mortality agents, such as the spruce beetle. Severe cases of defoliation alone may result in tree mortality. Spruce in urban settings and along marine shorelines are most seriously impacted. Spruce aphids feed primarily in the lower, innermost portions of tree crowns, but may impact entire crowns during outbreaks. Outbreaks in southeast Alaska are usually preceded by mild winters.

An outbreak occurred in 1998 following a mild winter. In 2000, 39,400 acres of defoliation were detected, almost as many acres as in 1998. Seventy-five percent of these acres (29,500 acres) were on national forest lands. The defoliation in 2000 was primarily on south to west facing slopes.

Map 4. Spruce Aphid Defoliation Map.



In 2001, 20,200 acres of beach fringe trees were infested along the mainland from the Stikine River to Yakutat Bay. Admiralty, Douglas, Hecata, and Wrangell Islands were also infested. The most notable urban area outbreaks were in Juneau and Wrangell. A short period of zero temperature in March did not kill overwintering adults. The population began to build toward the end of April to the degree that winged adults were present in July. Trees with spruce aphids often had large conifer aphids. Tree mortality occurred in the Juneau area.



Figure 10. Spruce aphid feeding on a spruce needle.

Western Black-headed Budworm

Acleris gloverana Walsingham

The black-headed budworm occurs primarily in southeast Alaska and has been documented there since the early 1900s. Occasional, extensive outbreaks of this forest pest occur in other coastal areas of the State as well, including the Turnagain Arm of Cook Inlet, Prince William Sound, and southwestern Alaska. Though western hemlock is usually the primary host, western black-headed budworm also impact Sitka spruce, white spruce, and mountain hemlock. Historically, outbreaks of western black-headed budworm are highly cyclic, characterized by rapid increases in number followed, in 1–5 years, by equally

rapid declines. Budworm populations appear to be highly susceptible to adverse weather conditions.

In southwestern Alaska, 2001 aerial surveys detected 30,000 acres of white spruce defoliation attributable to western black-headed budworm in the Wood River–Tikchik State Park, specifically from Nunavaugaluk Lake north to Lake Nerka. Within the State Park: Grant Lake reported 5,271 acres of light defoliation; Lake Nerka, 17,677 acres of light and medium defoliation; Lake Aleknagek had 2,486 acres of light defoliation and 3,703 acres of heavy defoliation; while Nunavaugaluk Lake reported 1,184 acres of light defoliation. The last time budworm defoliation was detected in this area was in 1979, when nearly 3,000 acres of white spruce defoliation were noted in the Lake Kulik–Grant Lake area. No further evidence of that outbreak was found the following year.

In Prince William Sound this year, nearly 21,000 acres of hemlock defoliation was noted from the Copper River Delta to Valdez Narrows. The breakdown is as follows: Valdez Arm, 4,769 acres; Bligh Island, 935 acres; Tatitlek, 515 acres; Boulder Bay, 299 acres; Landlocked Bay, 722 acres; Port Fidalgo, 1,186 acres; Port Gravina, 2,340 acres; Orca Bay, 138 acres; and Hawkins Island, 564 acres. East of Cordova, between Sheridan Glacier and the Copper River, 4,227 acres of defoliation were observed, while along the Martin River, 3,782 acres of defoliation were reported.

In southeast Alaska, a peak year for budworm defoliation occurred in 1993, totaling 258,000 acres. The last budworm outbreak of this magnitude occurred from the late 1940's to mid-1950. Black-headed budworm populations crashed in 1995. Since 1998 no budworm defoliation was reported in southeastern Alaska.

Hemlock Sawfly

Neodiprion tsugae Middleton

Hemlock sawfly, a common defoliator of western hemlock, is found throughout southeast Alaska. Historically, sawfly outbreaks in southeast Alaska have been larger and of longer duration in areas south of Frederick Sound. In 1999, sawfly defoliation was virtually nonexistent, this coming after a peak in 1997 when 2,500 acres were recorded.

In 2000, most of the 5,200 acres of activity occurred in “hot spot locations” in Kasaan Bay, Prince of Wales Island, Burroughs Bay north of Ketchikan, and

Windham Bay east of Admiralty Island. In 2001, most of the 1,260 acres were infested south of Fredrick Sound.

Unlike the larvae of the black-headed budworm, hemlock sawfly larvae feed in groups, primarily on older hemlock foliage. These two defoliators, feeding in combination, have the potential to completely defoliate western hemlock. Heavy defoliation of hemlock by sawflies is known to cause reduced radial growth and top-kill. Hemlock sawflies may ultimately influence both stand composition and structure. The sawflies themselves are a food source for numerous birds, other insects, and small mammals.

Spruce Budworm and Coneworm

Choristoneura fumiferana (Clemens)

Choristoneura orae (Freeman)

Dioryctria reniculelloides Mutuura & Munroe

Zeiraphera spp.

During aerial surveys in 2000, nearly 41,000 acres of defoliated white spruce along the Christian River were mapped. No evidence of this outbreak was observed during 2001 surveys. Activity along the Tanana and Teklanika Rivers continues but the large Yukon River outbreak of several years ago appears to be over. Nearly 9,500 acres of light spruce budworm defoliation was mapped along the Teklanika River approximately 5 miles southwest of Nenana, while 16,000 acres of light to moderate defoliation was observed along the Tanana River extending from the mouth of the Kantishna River, northeast and along the Tanana River to Grassy Lake.

Larch Sawfly

Pristiphora erichsonii (Hartig)

In 2001, larch sawfly activity continued a decline that began in 1999 when sawfly populations impacted nearly 450,000 acres. This year, larch sawfly defoliation fell to 17,821 acres, down from the 64,859 acres reported in 2000 (minus 73 percent). The steady decline of this infestation is due to massive mortality incurred by native larch in interior Alaska. Throughout the course of this infestation, first observed during aerial surveys in the summer of 1993, over 200,000 acres of larch have been affected by substantial mortality. Eight years of increasingly heavy defoliation has taken its toll on these vast stands of larch. The most heavily impacted area is in the

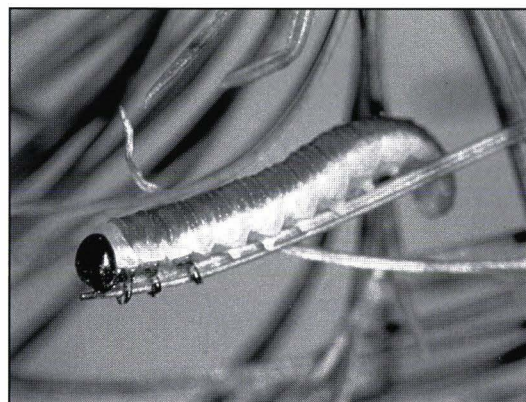


Figure 11. Larch sawfly larva.

“Farewell Burn,” between the Alaska Range and the Kuskokwim River south of McGrath where one can now fly for miles without seeing a live larch. With the exception of 445 acres of heavy defoliation approximately 10 miles northeast of McGrath along the Kuskokwim River, and 606 acres of light activity along the mid-portion of the Kantishna River, the remaining 16,707 acres of larch defoliation is occurring on or just outside the Innoko National Wildlife Refuge. It is reasonable to assume that if active defoliation continues in this area, these stands too, will incur considerable mortality. A biological evaluation conducted in August 2000 within the Innoko National Wildlife Refuge by Forest Health Protection staff found that within the areas studied, 70 percent of the live larch were 70 percent plus defoliated, while 27 percent of the total component of larch had died. It was presumed that larch suffering repeated seasons of defoliation would be predisposed to attack by larch beetle, but apparently, this has not happened. The mortality incurred seems to be primarily attributable to larch sawfly defoliation.

In south-central Alaska, the larch sawfly has continued its advance southward affecting ornamental Siberian Larch plantings from Sterling to Homer on the Kenai Peninsula. In what appeared to be an accidental introduction, first noted in the MatSu Valley and within the Municipality of Anchorage (Anchorage Bowl, Eagle River) during 1999 surveys by Cooperative Extension technicians, this pest of native larch, in interior Alaska, has apparently established a solid foothold south of the Alaska Range into south-central Alaska’s urban and community forest areas. While larch is not native to the Kenai Peninsula, it is a popular landscape tree. In several cases reported to Alaska Division of

Forestry, private contractors initiated chemical controls. However, several other reports indicated that remedial and cultural measures such as water sprays, insecticidal soaps, and fertilizing and watering regimens were equally effective in urban situations. The ornamental (Siberian) larch plantings appear to be less susceptible to stress from repeated defoliation by the sawfly and are responding better to nonchemical control measures. Expansion of the larch sawfly into the south-central Alaska urban areas has been swift and it appears that eradication is not feasible or practical. Additional tracking of this expansion will be continued to see if the introduction of biological controls (parasites, predators) might be warranted.

Aspen Leaf Miner

Phyllocnistis populiella (Chambers)

Widespread, intensive defoliation of aspen by the aspen leaf miner was noticeable, for the second consecutive year, throughout interior Alaska, especially from the Tanana Valley south to Eagle and east into the Yukon Territory, Canada.

Meandering larval mines are produced in the epidermal layers on the undersides of leaves. Such mining reduces the photosynthetic area of the affected leaves. Heavy repeated attacks reduce tree growth and may cause some top-kill.

Adult moths overwinter under bark scales of aspen. Adults emerge in early June and deposit eggs singly on the leaf edge then slightly fold the leaf to form a protective covering for the egg until larval emergence. The newly hatched larvae bore into and feed between epidermal leaf tissues. Pupation occurs within the larval leaf mines. Adult emergence occurs prior to or sometimes after the leaves drop in late August and September.

Birch Defoliation

Fenusa pusilla (Lepelletier)

For the fifth consecutive year, birch defoliation was very noticeable in the Anchorage Bowl from late July to August. Although these hardwoods have been defoliated for several consecutive years, as yet there doesn't appear to be any lasting damage.

The causal agent appears to be *Fenusa pusilla*, although this identification is tentative. It appears that this leaf miner is a recent introduction into the

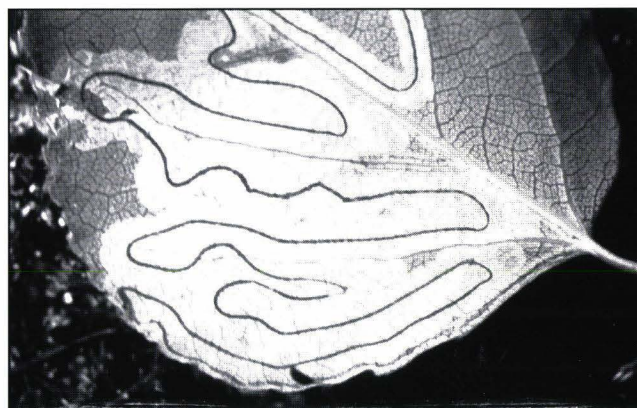


Figure 12. Larval galleries of the aspen leaf miner, *Phyllocnistis populiella*.

Anchorage Bowl: it was not observed before 1996 and is only concentrated in the Anchorage Bowl area. It has not been observed in forest settings. This birch leaf miner was first reported in eastern United States in 1923. Introduced from Europe, it has spread rapidly throughout the northern United States, Canada, and recently into Alaska. The adult sawfly is black, about 3 mm long, and similar in appearance to a common fly. Larvae overwinter in cocoons in the soil and adults appear in the spring when the first birch leaves are half grown. The female sawfly deposits her eggs singly on newly developing leaves. At times, almost every leaf is mined by the developing larvae, giving it a brown color. When mature, the larva cuts a hole through the leaf and drops to the ground. There the larvae build a cell in which pupation takes place; 2–3 weeks are usually required for transformation into the adult stage. A reflushing of leaves may occur, and a second generation of egg-laying sawflies may develop. Two to four generations of this insect can develop in northeastern U.S.; the number of generations in Alaska is not known.

Large Aspen Tortrix

Choristoneura conflictana Wlkr.

Large aspen tortrix defoliated approximately 7,100 acres of aspen in south-central and interior Alaska during the summer of 2001. This figure is up moderately (plus 22 percent) from the 5,576 acres reported in 2000, but is consistent with the cyclic nature of populations of this insect. Five miles southwest of Willow, tortrix heavily defoliated 5,819 acres of aspen along the Susitna River. On the Yukon River, several

miles upriver from the village of Rampart, tortrix lightly defoliated nearly 1,000 acres of aspen in two discreet areas: 344 acres located 5 miles northwest of Rampart, and 652 acres at Chicago Lakes, 10 miles north of Rampart. The only other area of tortrix activity found during aerial surveys in 2001 was just off the Chitina River approximately 12 miles south of McCarthy where nearly 300 acres of aspen were lightly defoliated.

Cottonwood Defoliation

Chrysomela spp.

Epinotia solandriana L.

Cottonwood defoliation by the cottonwood leaf beetle (*Chrysomela*) was very heavy throughout south-central and interior Alaska. The black-colored leaf beetle larvae skeletonize the leaves of black cottonwood or poplar giving the trees a brown appearance. Over 9,000 acres were noted during the 2001 survey. The Anchorage Bowl and Seward area were most notable at nearly 5,000 acres but defoliation also occurred in the Coleen and Black River drainages.

In southeast Alaska, the majority of cottonwood defoliation on the west side of Russell Fiord near Yakutat was attributed to a leaf roller (*Epinotia solandriana*).

Willow Leaf Blotch Miner

Micrurapteryx salicifolliella (Chambers)

The outbreak of the willow leaf blotch miner continued in 2001 for the tenth consecutive year. This year, acres of defoliated willow have decreased considerably relative to last years figure of 36,000 acres. Only 10,864 acres of willow defoliation were mapped in 2001, representing a 60 percent decline over 2000 levels. The majority of the defoliated acreage this year (8,739 acres) was confined to the Yukon Flats Wildlife Refuge. Smaller active areas were located approximately 25 miles south of McCarthy along the Tana River (1500 acres) and along the Kantishna River (400 acres). The actual number of impacted acres is probably, much higher. In the past, this insect has been observed in many areas over the range of willow, particularly throughout the Yukon Flats National Wildlife Refuge. Time and monetary constraints do not allow full aerial survey coverage of this vast area, thus, large areas of willow away from the major river drainages are often overlooked. Though

past mortality is not mapped on these aerial surveys, it should be noted that a considerable amount of willow mortality has been observed throughout the Yukon Flats National Wildlife Refuge. This mortality is assumed to be a result of repeated years of heavy defoliation by the willow leaf blotch miner.

Ten species of willow have been observed infested, the severity of which differed somewhat between localities and species. Feltleaf willow, *Salix alaxensis*, is not infested due to the under leaf surface being covered by a protective felt-like mat of hairs that prevents attachment of blotch miner eggs.

Alder Woolly Sawfly

Eriocampa ovata (L.)

Moderate defoliation of Sitka and thin-leaf alder was observed for the fifth consecutive year in many parts of the Anchorage Bowl. Similar to the birch leaf miner, the alder woolly sawfly appears to be a recent (less than six years) introduction into the state. This sawfly is a European species now established throughout the northern U.S., Canada, and recently into Alaska. The larvae are covered with a distinctive shiny, woolly secretion. They skeletonize the lower leaves on young alders; the upper crown is usually not fed upon. Populations are expected to decline next year as a result of this summer's cool and wet conditions.



Figure 13. Woolly alder sawfly larva.

Invasive Pests

Those who follow the national media are already familiar with a few key invasive pests, primarily insects, which have been introduced into the western U.S. over the last two decades. Invasive pests (introduced nonindigenous plants, animals, insects, and microbes) are among the most serious threats to biological diversity in Alaska; although, to date, few invasive pests have been introduced and established in Alaska. Of concern is the movement of organisms from the continental U.S. into Alaska in light of climate change and increased commerce. Likewise, the movement of native insects and pathogens from one area to another, apparently geographically isolated, is also problematic. A warming trend may increase the probability that organisms accidentally introduced into Alaska will become established. Once established, invasive pest populations can become difficult to control and manage since the complement of parasites and predators that normally control their numbers are at low levels, or absent.

It is inevitable that we are going to see more and more introduced pests “invading” both rural and urban forest areas of Alaska. If pest introductions are left to “run their course” or if we are not prepared to expend the efforts to safeguard our ecosystems, Alaska will be poorer in terms of resources and biological diversity. For example, without eradication efforts, many invasive insects could inadvertently become a dominant influence affecting native species of both pest and nonpest insect populations. The ability of many introduced pests to out-compete or displace the native species will complicate Integrated Pest Management (IPM) efforts already in place. USDA Animal & Plant Health Inspection Service (APHIS), the State of Alaska divisions of Agriculture and Forestry (AKDOF), University of Alaska Cooperative Extension Service (CES), and the USDA Forest Service, Forest Health Protection already have small programs in place to monitor and detect potential insect or plant introductions. Alaska residents, resource professionals, and land managers need to “keep a sharp eye” out for potential introduced pests and contact CES, APHIS, or AKDOF. If introduced pests are positively and quickly identified, the probability of successful eradication or IPM control efforts are increased.

While insect invasive pests are very obvious and direct in their effects on the habitat (and humans), most of the plant and disease invasives are initially less obvious or pervasive in their expansion into new habitats. Presently, most of the invasive plants are found in disturbed areas, primarily in the developed urban parks and on agricultural lands. Left unchecked, these invaders may overrun other disturbed areas, including forest harvest areas, field tree nurseries, etc., displacing native ground plant cover. Based on the CES reports, a number of weedy (plant) exotics are spreading through the urban forest and agricultural areas of Alaska at rates that are surprising, if not alarming, to many of the forest and agricultural pest and land management specialists working in Alaska. Many of these species have been introduced by accident into ecosystems where they thrive at the expense of native plant species by competing vigorously to displace the native species. Invasion is first over small areas, then over large areas as they dominate the local flora for available habitat. Most control problems are in areas with heavy human traffic such as along forest trails, ballparks, and other public areas. A major challenge is that seed can very efficiently be transported on shoes or clothing to other areas complicating control and eradication efforts.

To date, the initial work has been to establish a network for information flow on these often-unwelcome plant invaders. IPM specialists with CES have reported a number of plant exotics over the past several years that should help focus continued efforts. The first formal gathering of invasive and exotic plant researchers and specialists was held in Fairbanks in early 2001 to begin to address coordination of monitoring, control, and funding efforts for Alaska.

Based on records compiled over the last 2–3 years by Cooperative Extension Service (CES) Integrated Pest Management (IPM) specialists, introductions of invasive non-native plants to areas in and near Alaska’s forests should be monitored. The distinction of “noxious” plants can be made for several of these species in that they have been shown to interfere with management objectives for a given area of land over a given period of time. The CES specialists in Anchorage, Delta Junction, Fairbanks, Juneau, and the Kenai Peninsula identified the following species (see below) as various forms of “biological pollution” to our urban environment during the past few years. These

noxious plants and disease pests are becoming more noticeable and controls are being requested as people recognize that an introduced plant species can easily take over a planting. This is not an all-encompassing list of invasive “noninsect” species. With the exception of just a few species, the list does not have any regulatory implication. It is hoped that this list will serve to begin to track and provide additional information about invasive plants and diseases in future forest conditions reports, should they become of concern:

As reported by the Cooperative Extension Service during 1999-2001, the following species are currently on the State of Alaska Division of Agriculture’s regulatory list; some are prohibited * or restricted ** noxious weeds. The State of Alaska’s web site for the National Biological Information Infrastructure can be found at: <http://www.invasivespecies.gov/geog/state/ak.shtml>

Canada thistle, *Cirsium arvense* * (a large patch was located in a Municipality of Anchorage park area as well as several other locations around Anchorage during the 2001 field season)

Bishop’s weed, *Ptilimnium capillaceum*

Black knot, *Apiosporina morbosum*, on *Prunus* spp. (common on planting stock that has been outplanted for several years in Anchorage)

Butter-and-eggs, *Linnaria vulgaris*

Buttercup, *Ranunculus* spp.

Corn spurry, *Spergula arvensis*

Fire blight, *Erwinia amylovora* (seen on apple in 2000; potential for affecting other plants in the family Rosaceae, e.g., native mountain ash)

Horsetail, *Equisetum* spp.

Hawksbeard, *Crepis setosa*

Hempnettle, *Galeopsis tetrahit* *

Horsenettle, *Solanum carolinense* *

Japanese knotweed, *Polygonum cuspidatum*

Orange hawkweed, *Hieracium aurantiacum*

Perennial sowthistle, *Sonchus arvensis* *

Tufted Vetch, *Vicia cracca* **

Gypsy Moth

Lymantria dispar (L.)

The European gypsy moth was accidentally introduced into the eastern U.S. in the late 1800s and has been responsible for considerable damage to the hardwood forests of the east. The gypsy moth has also been introduced to the western U.S. where millions of dollars have been spent on its eradication.

Since 1986, Forest Health Protection, in conjunction with Alaska Cooperative Extension and USDA APHIS, has placed gypsy moth pheromone monitoring traps throughout Alaska. To date, only two European gypsy moths have been trapped in Alaska. As far as we know, populations of the gypsy moth have not been established in Alaska.

Due to the detection of the Asian gypsy moth (a more damaging race of the European gypsy moth) in the Pacific Northwest, more than 200 detection traps were placed throughout Alaska in 2001. No Asian or European gypsy moths were collected. If the Asian gypsy moth becomes established in the western U.S., including Alaska, the potential impacts to forest and riparian areas could be tremendous. The trapping program will be continued next year.



Figure 14. European gypsy moth larva.

Uglynest Caterpillar: Tortricidae

Archips cerasivorana (Fitch)

Cooperative Extension Service and Alaska Division of Forestry entomologists found the Uglynest caterpillar on Cotoneaster hedge plantings in west Anchorage, downtown and in south Anchorage. Adjacent mountain ash plantings at one location also sustained heavy branch dieback, apparently from initial caterpillar feeding. The insect has one generation per year, overwintering in the egg stage. The adult moths are active from June through August; the front wing is crossed with reddish brown striations and has an iridescent sheen; hind wings are bright orange. Larvae are yellowish to yellowish-green as they reach maturity with dark brown or black heads. All larval stages are gregarious and live in silk-covered tents or nests that become filled with frass as the larvae grow. This insect can be a problem in nurseries or ornamental plantings because of the unsightly appearance of the larval nests. The nests may also cause some branch deformity in subsequent years of heavy defoliation but little other permanent damage.

European Black Slug: Limacidae

Arion ater

The European black slug, an invertebrate, was detected twice in a local Anchorage garden in 2000, and again in 2001, and was likely imported on flats of bedding plants that originated from Washington State. Additional sightings were noted in Cordova this summer. A distinctive feature of this slug is the many grooves and ridges along the back. This reddish-brown slug has a distinctive striped red-orange skirt. When fully extended, this slug measures almost 6 inches in length. The European black slug is established in the northwest U.S. and is a serious pest of crops including corn, wheat, potatoes, beans and strawberries.



Figure 15. Uglynest caterpillar larvae.

Leopard Slug: Limacidae

Limax maximus

A slug (about 5 inches long and one-half inch diameter, tan-beige colored and with elongated black splotches all over its back except its mantle) was tentatively identified as a leopard slug last year. Local gardeners indicate that these slugs have been found about 15 miles north of Juneau for several years now. Populations were also observed in Cordova this summer.

Tufted Vetch

Vicca cracca L.

Do not be deceived by the pretty bluish-purple flowers. This climbing legume has been spotted growing aggressively around south Anchorage for the past several seasons, most notably along the Seward Highway. It is weak-stemmed with compound leaves and has a climbing habit that allows it to grow on and over other plants. It has been observed invading yards, other roadside locations, and along the Turnagain Arm trail in Chugach State Park and along the Glen Highway to Palmer. *Vicca cracca* is recognized as a restricted noxious weed by the State of Alaska. The easiest method to control this plant is by pulling it wherever encountered and bagging it up for disposal to ensure seeds are not left on site.



Figure 16. 2001 aerial surveys detected 30,000 acres of white spruce defoliation attributable to western black-headed budworm.



Figure 17. Areas of southeast Alaska experienced its fourth year of spruce aphid defoliation.



Figure 18. Uglynest caterpillar on Cotoneaster hedge plantings in Anchorage. All larval stages are gregarious and live in silk-covered tents.

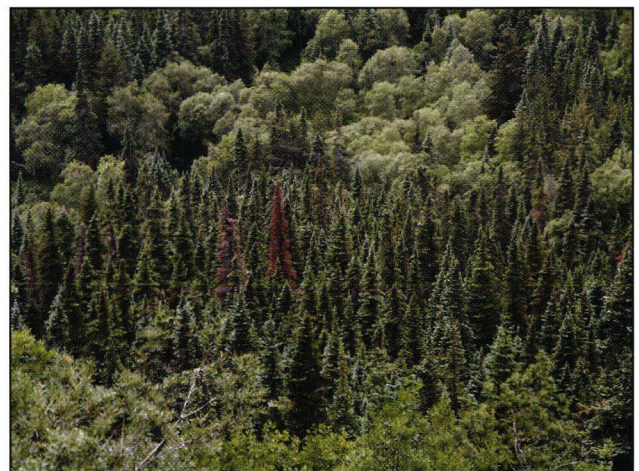
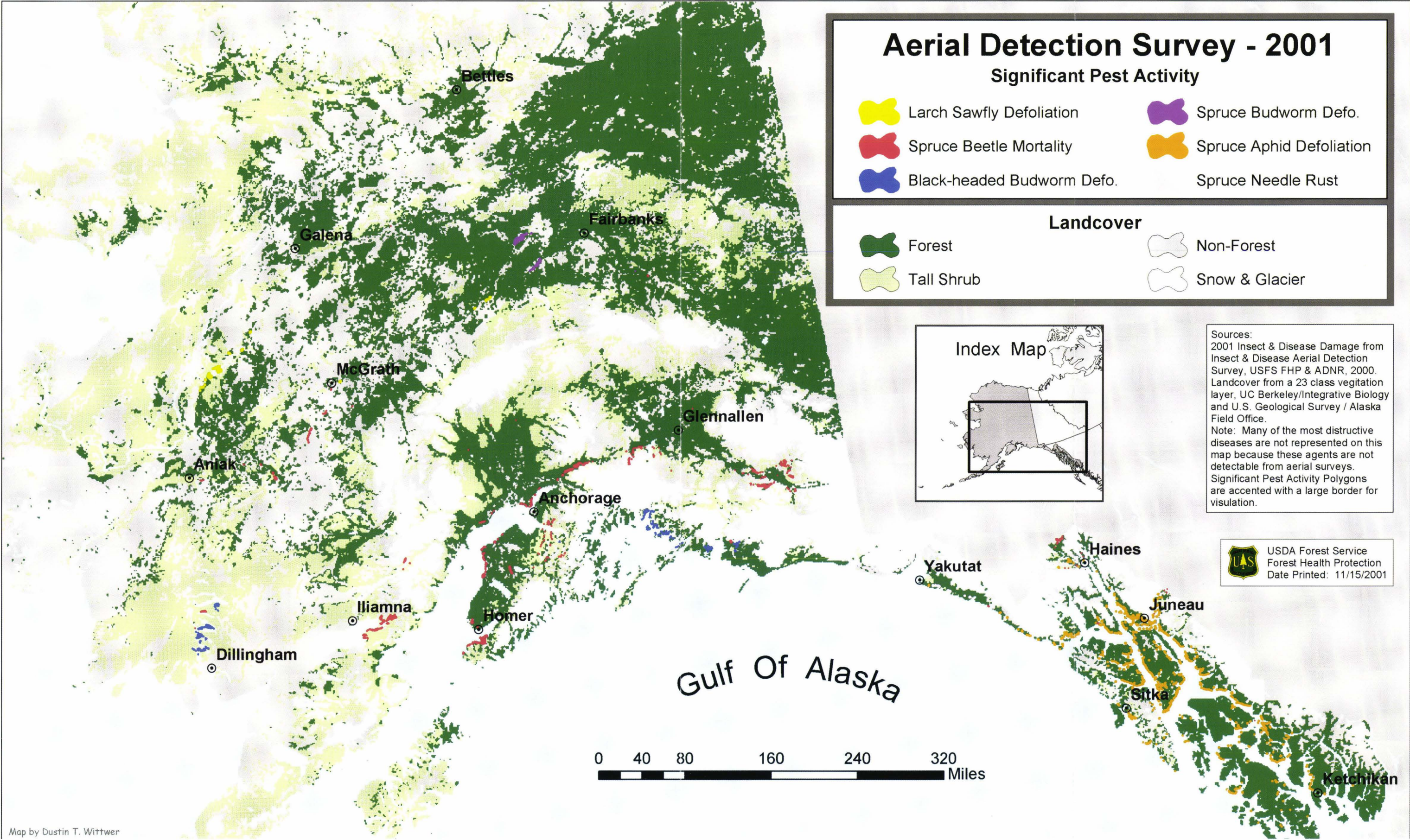


Figure 19. A small bark beetle outbreak on subalpine fir was noted north of Skagway.

Map 5. General Forest Pest Activity in 2001.



Map 6. 2001 Survey Flight Paths Showing Ownership.

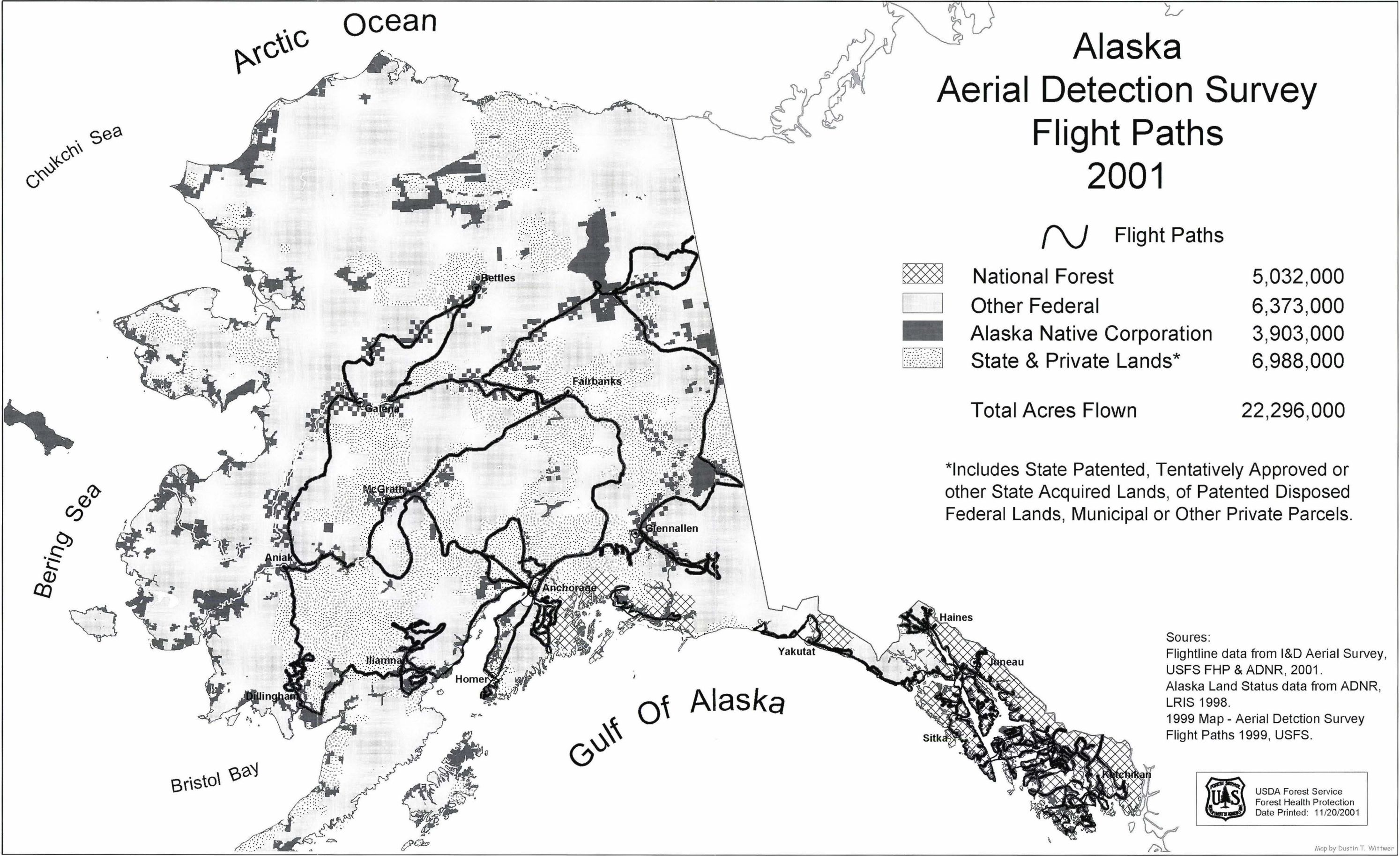




Figure 20. Chicken of the woods fruited prolifically this fall in the old-growth forests near Seldovia and throughout southeast Alaska. This fungus causes a brown rot in the lower stem of infected trees.



Figure 22. Fruiting bodies of the velvet top fungus, *Phaeolus schweinitzii*, indicate substantial wood decay in the lower stem and a high potential for bole breakage.



Figure 21. Hemlock canker was evident along several shoreline and roadside locations in 2001.



Figure 23. Yellow-cedar decline is distributed across a spectrum of stand types including this “scrubby” condition.

Ecological Roles of Forest Diseases

The economic impacts of forest diseases in Alaska have been recognized for some time. In southeast Alaska, heart rot fungi cause substantial cull of nearly one-third of the gross volume in old-growth hemlock-spruce forests. In the south-central and interior regions, substantial cull from decay fungi also occurs in white spruce, paper birch, and aspen forests. Traditionally, management goals sought to eliminate or reduce disease to minimal levels in an effort to maximize timber outputs. As forest management goals broaden to include enhancement of multiple resources and retaining structural and biological diversity, forest disease management can be assessed from an ecological perspective.

We are learning that diseases are key ecological factors in Alaskan ecosystems. They enhance biological diversity, provide wildlife habitat, and alter forest structure, composition, and succession. As agents of disturbance in the western hemlock–Sitka spruce forests of southeast Alaska, diseases apparently contribute to the “breaking up” of even-aged stands as they are in transition (i.e., 150 to 200 years old) to old-growth phase. Diseases appear to be among the primary factors that maintain stability in the old-growth phase through small-scale (canopy-gap) level disturbance. Less is known about the ecological role of diseases in south-central and interior forests, however diseases appear to be agents of small-scale disturbance altering ecological processes in spruce and hardwood forests.

Forest practices can be used to alter the incidence of diseases to meet management objectives. Two of the principal types of conifer disease that influence forest structure in Alaska, heart rot and dwarf mistletoe, can apparently be managed to pre-

dictable levels. If reducing disease to minimal levels is a management objective, then both heart rot and mistletoe can be largely eliminated through clearcut harvesting and even-aged management. However, to reduce disease to minimal levels in all instances is to diminish the various desirable characteristics of forest structure and ecosystem functions that they influence. Heart rot organisms and dwarf mistletoe provide unique forest structural components that may be lost for decades or perhaps centuries after clearcutting. Research indicates that harvesting practices other than clearcutting can be used to retain structural and biological diversity by manipulating these diseases to desired levels. Since heart rot in coastal stands is associated with natural bole scars and top breakage, levels of heart rot can be manipulated by controlling the incidence of bole wounding and top breakage during stand entries for timber removal. Levels of dwarf mistletoe can be manipulated through the distribution, size, and infection levels of residual trees that remain after harvest. Our ongoing research indicates that the incidence and effects of these diseases will vary through time in a predictable manner by whatever silvicultural strategy is used.

Research is currently underway in south-central and interior Alaska to assess the economic and ecological impacts of root diseases. Root diseases are difficult to detect, remain active on site in trees and stumps for

decades, infect multiple age classes, and cause substantial volume loss. Ecologically, root diseases create canopy gaps that contribute to biodiversity, provide wildlife habitat, and alter successional processes.

Elimination of root rot from an infected site is challenging because the diseased material is primarily located in buried root systems. Establishment of nonhost material within root rot centers is an effective option for manipulating levels of root disease. Ongoing research on



Figure 24. Decay fungi play vital roles in recycling nutrients and producing habitat.

the relationship between species composition and root disease incidence in south-central and interior Alaska will provide important information to forest managers for both ecological and economic considerations for disease management.

Table 3. Suspected effects of common diseases on ecology in Alaskan forests.

Disease	Ecological Function Altered			
	Structure	Composition	Succession	Wildlife Habitat
Stem Diseases				
Dwarf Mistletoe	●	◐	◐	●
Hemlock Cankers	○	◐	○	◐
Hardwood Cankers	◐	◐	◐	○
Spruce Broom Rust	◐	○	○	●
Hemlock Bole Fluting	○	○	○	◐
Western Gall Rust	○	○	○	○
Heart Rots				
(Many Species)	●	◐	●	●
Root Diseases				
(Several Species)	◐	●	●	◐
Foliar Diseases				
Spruce Needle Rust	○	○	○	○
Spruce Needle Blights	○	○	○	○
Hemlock Needle Rust	○	○	○	○
Cedar Foliar Diseases	○	○	○	○
Hardwood Leaf Diseases	○	○	○	○
Shoot Diseases				
Sirococcus Shoot Blight	○	○	○	○
Shoot Blight of Yellow-Cedar	○	◐	○	○
Declines				
Yellow-Cedar Decline	●	●	●	◐
Animal Damage				
Porcupines	◐	○	○	◐
Brown Bears	◐	○	○	◐
Moose	◐	◐	○	◐

Effects by each disease of disorder are qualified as:
negligible or minor effect = ○;
some effect = ◐;
dominant effect = ●.

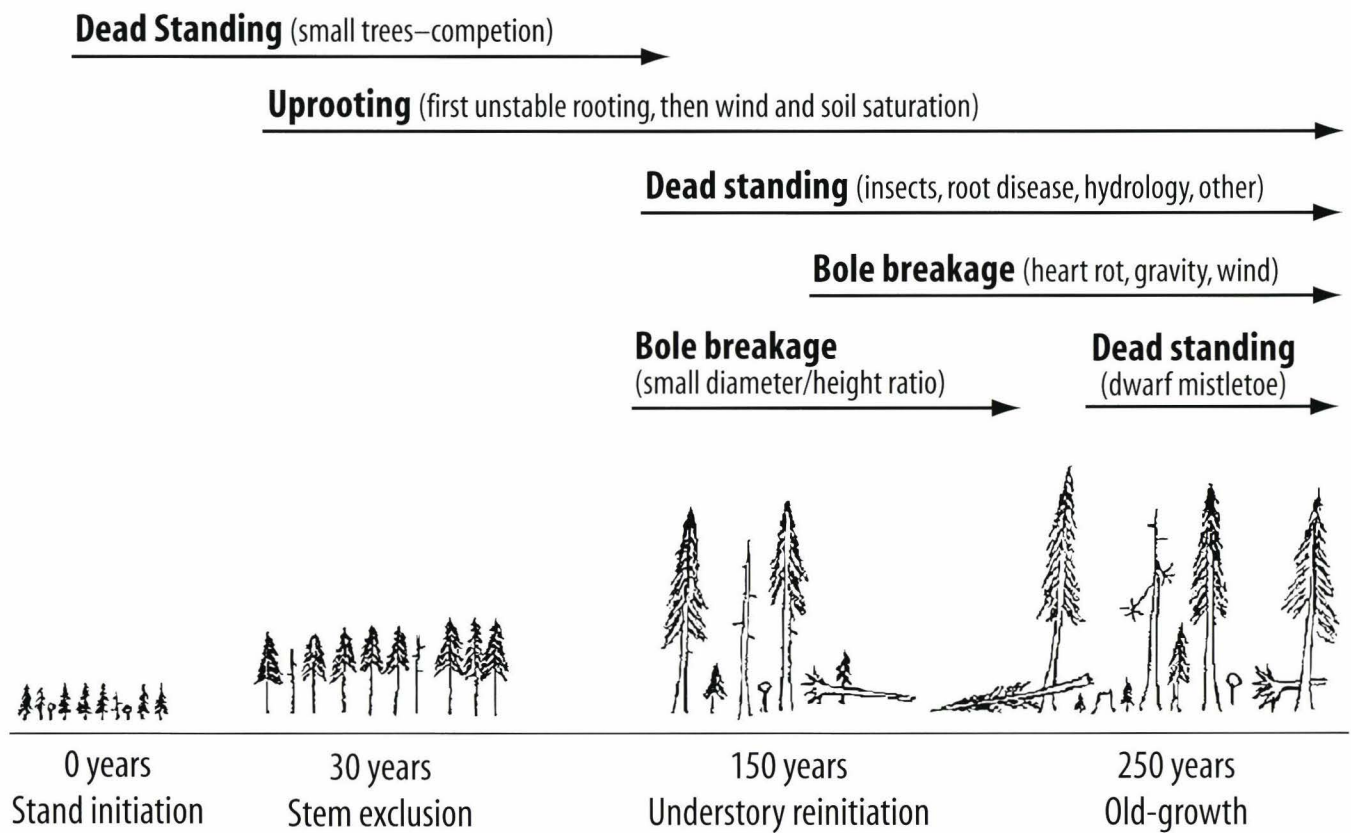


Figure 25. Stages of stand development and associated forms of tree mortality following catastrophic disturbance (e.g., clearcut or storm). Competition causes most mortality in young stands and trees usually die standing. Disease in the form of heart rot plays an active role in small-scale disturbance in the third, transitional stage and then is a constant factor in the maintenance of the old-growth stage. The time scale that corresponds to stages of stand development varies by site productivity. Many old-growth structures and conditions may be present by 250 years on some sites in southeast Alaska. The old-growth stage may persist for very long periods of time in protected landscape positions.

Stem Diseases

Hemlock Dwarf Mistletoe

Arceuthobium tsugense (Rosendhal) G.N. Jones

Hemlock dwarf mistletoe is an important disease of western hemlock in unmanaged old-growth stands throughout southeast Alaska as far north as Haines. Although the range of western hemlock extends to the northwest along the Gulf of Alaska, dwarf mistletoe is absent from Cross Sound to Prince William Sound. The incidence of dwarf mistletoe in southeast Alaska varies in old-growth hemlock stands in south-east Alaska from stands in which every mature western hemlock is severely infected to other stands in which the parasite is absent. The dominant small-scale (canopy gap) disturbance pattern in the old forests of coastal Alaska favors the short-range dispersal mechanism of hemlock dwarf mistletoe and may explain the common occurrence of the disease here. Infection of Sitka spruce is uncommon and infection of mountain hemlock is rare. The disease is uncommon on any host above elevations of approximately 1,000 feet. Heavily infected western hemlock trees have branch proliferations “witches’ brooms,” bole deformities, reduced height and radial growth, less desirable wood characteristics, greater likelihood of heart rot, top-kill, and severely infected trees may die. We have found the aggressive heart rot fungus, *Phellinus hartigii*, associated with large mistletoe brooms on western hemlock.

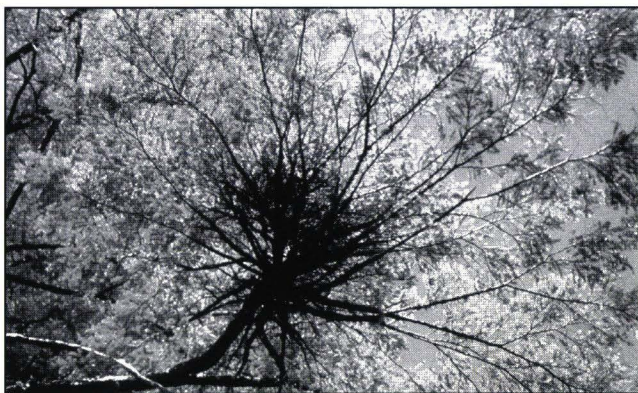


Figure 26. Hemlock dwarf mistletoe is a parasitic plant that causes the host tree to form “broom” like branches.

These symptoms are all potential problems in stands managed for wood production. Growth loss in heavily infested stands can reach 40 percent or more. On the other hand, witches’ brooms, wood decay associated with bole infections, and scattered tree mortality can result in greater diversity of forest structure and increased animal habitat. Witches’ brooms may provide hiding or nesting habitats for birds or small mammals, although this topic has not been adequately researched in Alaska. The inner bark of swellings and the seeds and shoots of the parasitic plants are nutritious and often consumed by small mammals (e.g., most likely flying squirrels). However, heavily infected hemlock stands can begin to decline and collapse to the extent that vertical structural diversity and animal habitat are diminished. Stand composition is altered when mixed-species stands are heavily infected; growth of resistant species such as Sitka spruce and cedar is enhanced.

Spread of the parasite into young-growth stands that regenerate following “clear cutting” is typically by: 1) infected nonmerchantable hemlock trees (residuals) which are sometimes left standing in cutover areas, 2) infected old-growth hemlocks on the perimeter of cutover areas, and 3) infected advanced reproduction. Residual trees may play the most important role in the initial spread and long-term mistletoe development in young stands. Managers using alternative harvest techniques (e.g., large residuals left standing in clearcuts, small harvest units, or partial harvests) should recognize the potential reduction in timber volume and value from hemlock dwarf mistletoe under some of these silvicultural scenarios. But substantial reductions to timber are only associated with very high disease levels. High levels of hemlock dwarf mistletoe will only result if numerous, large, intensely infected hemlocks are well distributed after harvest. Mistletoe management appears to be a good tool in balancing several resource objectives. Selective harvesting techniques will be the silvicultural method for maintaining desirable levels of this disease if management intends to emphasize structural and biological diversity along with timber production.

Spruce Broom Rust

Chrysomyxa arctostaphyli Diet.

Broom rust is common on spruce throughout interior and south-central Alaska, but is found in only several local areas of southeast Alaska (e.g., Halleck Harbor area of Kuiu Island and Glacier Bay).

The disease is abundant only where spruce grows near the alternate host, bearberry or kinnikinnick (*Arctostaphylos uva-ursi*) in Alaska. The fungus cannot complete its life cycle unless both host types (spruce and bearberry) are present.

Infections by the rust fungus result in dense clusters of branches or witches' brooms on white, Lutz, Sitka, and black spruce. The actual infection process may be favored during specific years, but the incidence of the perennial brooms changes little from year to year. The disease may cause slowed growth of spruce, although this has not been determined by research. Witches' brooms may serve as entrance courts for heart rot fungi, including *Phellinus pini*.

Ecologically, the dense brooms provide important nesting and hiding habitat for birds and small mammals. In interior Alaska, research on northern flying squirrels suggests that brooms in white spruce are an important habitat feature for communal hibernation and survival in the coldest periods of winter.



Figure 27. Western gall rust on a shore pine branch.

Western Gall Rust

Peridermium barknessii J.P. Moore

Infection by the gall rust fungus *P. barknessii* causes spherical galls on branches and main boles of shore pine. The disease was common throughout the distribution of pine in Alaska in 2001. Infected pine tissues are swollen but not always killed by the rust fungus. Another fungus, *Nectria macrospora*, colonized and killed many of the pine branches with *P. barknessii* galls this year. The combination of the rust fungus and *N. macrospora* frequently caused top-kill. The disease, although abundant, does not appear to have a major ecological effect in Alaskan forests.

Heart Rots of Conifers

Heart rot decay causes enormous loss of wood volume in Alaskan forests. Approximately one-third of the old-growth timber volume in southeast Alaska is defective largely due to heart rot fungi. These extraordinary effects occur where long-lived tree species predominate, such as old-growth forests in southeast Alaska. The great longevity of individual trees allows ample time for the slow-growing decay fungi to cause significant amounts of decay. Wood decay fungi play an important role in the structure and function of coastal old-growth forests where fire and other forms of catastrophic disturbance are uncommon. By predisposing large old trees to bole breakage, these fungi serve as important disturbance factors that cause small-scale canopy gaps. All major tree species in southeast Alaska are susceptible to heart rot decay and bole breakage.

In south-central and interior Alaska heart rot fungi cause considerable volume loss in mature white spruce and hardwood forests. Most heart rot fungi apparently enter trees through dead or broken branches, frost cracks, or bole wounds. In the boreal forests, large-scale disturbance agents, including wild-fire, insect outbreaks (e.g., spruce beetle), and flooding, are key factors influencing forest structure and composition. Although, small-scale disturbances from the decay fungi are less dramatic, they have an important influence on altering biodiversity and wildlife habitat at the individual tree and stand level.

Heart rot fungi enhance wildlife habitat—indirectly by increasing forest diversity through gap formation and more directly by creating hollows in live trees



Figure 28. *Fomitopsis pinicola* is an important heart rot fungus in live trees, but also the dominant decomposer of dead conifer trees.

or logs for species such as bears and cavity nesting birds. Wood decay in both live and dead trees is a center of biological activity, especially for small organisms. Wood decay is the initial step in nutrient cycling of wood substrates, has associated bacteria that fix nitrogen, and contributes large masses of stable structures (e.g., partially modified lignin) to the humus layer of soils.

The importance of decay fungi in managed young-growth conifer stands is less certain. Wounds on live trees caused by logging activities allow for the potential of decay fungi to cause appreciable losses. Heart rot in managed stands can be manipulated to desirable levels by varying levels of bole wounding and top breakage during stand entries. In some instances, bole breakage is sought to occur in a specific direction (e.g., across streams for coarse woody debris input). Artificially wounding trees on the side of the bole that faces the stream can increase the likelihood of tree fall in that direction. In southeast Alaska, we investigated how frequently fungi enter wounds of different sizes

and the rate of subsequent decay in these wounded trees. Generally, larger, deeper wounds and larger diameter breaks in tops result in a faster rate of decay. Results indicate that heart rot development is much slower in southeast Alaska than areas studied in the Pacific Northwest.

Wood decay fungi decompose branches, roots, and boles of dead trees; therefore, they play an essential role in recycling wood in forests. However, sap rot decay also routinely and quickly develops in spruce trees attacked by spruce beetles. Large amounts of potentially recoverable timber volume are lost annually due to sap rot fungi on the Kenai Peninsula. Significant volume loss from sap rot fungi typically occurs several years after tree death. The most common sap rot fungus associated with spruce beetle-caused mortality is *Fomitopsis pinicola*, the red belt fungus.



Figure 29. *Phellinus pini* is a common heart rot agent of conifers.

Table 4. Common wood decay fungi on live trees in Alaska

Heart and butt rot fungi*	Tree Species Infected				
	Western hemlock	Sitka spruce	Western red cedar	White/Lutz spruce	Mountain hemlock
<i>Laetiporus sulphureus</i>	X	X		X	X
<i>Phaeolus schweinitzii</i>	X	X		X	
<i>Fomitopsis pinicola</i>	X	X		X	X
<i>Phellinus hartigii</i>	X				
<i>Phellinus pini</i>	X	X		X	X
<i>Ganoderma</i> spp.	X	X		X	
<i>Coniophora</i> spp.				X	X
<i>Armillaria</i> spp.	X	X	X	X	X
<i>Inonotus tomentosus</i>				X	
<i>Heterobasidion annosum</i>	X	X			
<i>Ceriporiopsis rivulosa</i>			X		
<i>Phellinus weirii</i>			X		
<i>Echinodontium tinctorium</i>					X

* Some root rot fungi were included in this table because they are capable of causing both root and butt rot of conifers.



Figure 30. Shelf-shaped conk of the stem decay fungus *Phellinus igniarius* on paper birch.

Stem Decay of Hardwoods

Stem decay is the most important cause of volume loss and reduced wood quality in Alaskan hardwood species. In south-central and interior Alaska incidence of stem decay fungi increases as stands age and is generally high in mature stands. The most reliable decay indicator is the presence of fruiting bodies (mushrooms or conks) on the stem. Other external indicators of decay include frost cracks, broken tops, dead-broken branches, and poorly healed trunk wounds. Stem decay fungi will limit harvest rotation age of forests that are managed for wood production purposes.

Studies have been completed in paper birch forests that identified the most important stem decay fungi and assessed decay incidence as related to stand age, and presence of decay indicators.

Ecologically, stem decay fungi alter stand structure and composition and appear to be important factors in the transition of even-aged hardwood forests to mixed species forests. Bole breakage of hardwoods creates canopy openings, allowing release of understory conifers. Trees with stem decay, broken tops, and collapsed stems are preferentially selected by wildlife for cavity excavation. Several mammals, including the northern flying squirrel, are known to use tree cavities year-round for nest and cache sites.

In south-central and interior Alaska the following fungi are the primary cause of wood decay in live trees:

Paper birch

Phellinus igniarius
Inonotus obliquus
Pholiota sp.
Armillaria sp.

Trembling aspen

Phellinus tremulae
Pholiota sp.
Ganoderma applanatum
Armillaria sp.

A number of fungi cause stem decay in balsam poplar, black cottonwood, and other hardwood species in Alaska.

Shoot Blights and Cankers

Sirococcus Shoot Blight

Sirococcus strobilinus Pruess.

The shoots of young-growth western hemlocks were killed in moderate levels by the blight fungus *S. strobilinus* in southeast Alaska during 2001. Sitka spruce and mountain hemlock were attacked, but less frequently and less severely. Thinning may be of some value in reducing damage by the fungus as thinned stands have fewer infections than unthinned stands.

This disease is typically of minimal ecological consequence because infected trees are not often killed and young hemlock stands are so densely stocked. Species composition may be altered to some degree where trees other than western hemlock may be favored by the disease.

Shoot Blight of Yellow-cedar

Apostrasseria sp.

Yellow-cedar regeneration suffered infection and shoot blight by the fungus *Apostrasseria* sp. in southeast Alaska in 2001 as it does every year. The disease, however, does not affect mature cedar trees. Attack by the fungus causes terminal and lateral shoots to be killed back 10 to 20 cm on seedlings and saplings during winter or early spring. Entire seedlings up to 0.5m tall are sometimes killed. The newly discovered fungus that causes the disease, *Apostrasseria* sp., is closely related to other fungi that cause disease on plants under snow. Frost or insect feeding can sometimes be confused with this shoot blight disease.

The fungus *Herpotrichia juniperi* is often found as a secondary invader on seedling tissues that die from any of these causes.

This shoot blight disease probably has more ecological impact than similar diseases on other host species because the natural regeneration of yellow-cedar is limited in many areas. By killing the leaders of yellow-cedar seedlings and diminishing their ability to compete with other vegetation, the pathogen reduces the regeneration success of yellow-cedar and thereby alters species composition.

Canker Fungi

Cryptosphaeria populina (Pers.) Sacc.

Cenangium singulare (Rehm.) D. & Cash

Ceratocystis fimbriata Ell. & Halst.

Cytospora chrysosperma Pers. ex Fr.

Nectria galligena Bres.

All the canker-causing fungi were at endemic levels in 2001. These fungi cause perennial stem deforming cankers and wood decay of many hardwood species, particularly trembling aspen, in south-central and interior Alaska. Although most are considered weak parasites, *C. singulare* can girdle and kill a tree in three to ten years. *N. galligena* causes perennial "target" cankers particularly on paper birch. A low incidence of wood decay is associated with infection by this canker fungus. Ecologically, canker fungi alter stand structure, composition, and successional patterns through trunk deformity and bole breakage.

Hemlock Canker

Hemlock canker flared up in 2001 compared to last year's endemic levels. This year, it was evident along roads of several islands. In past outbreaks, it has been common along unpaved roads on Prince of Wales Island, Kuiu Island (Rowan Bay road system), Chichagof Island (Corner Bay road system), and near Carroll Inlet on Revillagigedo Island. It was also observed in several roadless areas. In 2001, several small stands were noted and mapped along roadsides and shoreline areas of central Prince of Wales and Etolin Island. Nearly seventy acres were mapped along the West Arm of Cholmondely Sound.

The causal agent has not been conclusively determined. Road dust and a fungus (that we have isolated to pure culture but not identified) appear to be responsible for outbreaks of this disease. Ecologically, modification of stand composition and structure are the primary effects of hemlock canker. Tree species, other than western and mountain hemlock (i.e., often Sitka spruce) are resistant and benefit from reduced competition. Wildlife habitat, particularly for deer, may be enhanced where the disease kills understory hemlock which tends to out-compete the more desirable browse vegetation.

Foliar Diseases

Spruce Needle Rust

Chrysomyxa ledicola Lagerh.

Chrysomyxa weirii Jacks.

Spruce needle rust, caused by *C. ledicola*, occurred at endemic levels across the State except in southeast where the disease was found at very high levels in specific locations. This year, an outbreak was mapped on approximately 10,000 acres between Yakutat Bay and Icy Bay along the Gulf of Alaska.

The disease is always most common wherever spruce and Labrador tea coexist on wet, boggy soils. Up to 100 percent of current-year's spruce needles were infected in many of these areas. With missing needles from the outbreaks in the last few years, spruce trees now have a rather thin appearance. Buds were not infected, however, and even with such high disease levels, most trees should recover.

The spores that infect spruce needles are produced on the alternate host, Labrador tea (*Ledum* spp.), a plant that is common in boggy areas; thus the disease on spruce is most pronounced in these boggy (muskeg) areas. Although the disease can give spruce trees the appearance of being nearly dead, trees rarely die of this disease even in years of intense infection.

On Sitka spruce, the primary ecological consequence

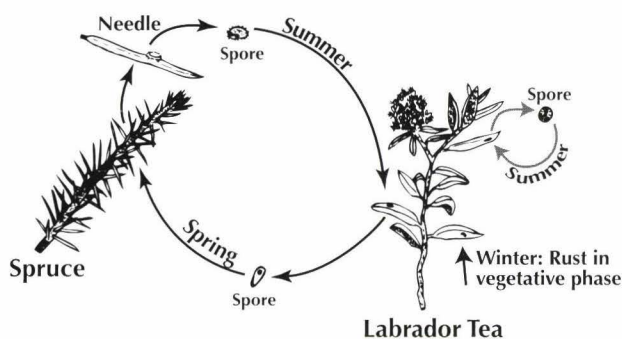


Figure 31. The life cycle of *C. ledicola* involves two host plants: spruce and Labrador tea.

of the disease may be to reduce tree vigor of a species already poorly adapted to boggy sites. Repeated infection of spruce may alter forest composition by favoring other tree species.

The foliar rust fungus *C. weirii* was found sporulating on one-year-old Sitka spruce needles in several areas of southeast Alaska during spring. Unlike most other rust fungi, no alternate host is necessary to complete its life cycle. Little ecological or economic impact results from this disease.

Hemlock Needle Rust



Figure 32. The yellow fruiting bodies of *Chrysomyxa ledicola* can be seen on the current year needles of this spruce.

Pucciniastrum vaccinii (Rab.) Joerst.

Hemlock needle rust was found at low endemic levels in 2001 after a high incidence several years ago. In 1996, the disease was most damaging near Yakutat where it caused defoliation of western hemlock, especially on trees growing adjacent to harvested sites. Elsewhere, infected needles were found, but hemlock trees were not heavily defoliated. The alternate hosts for the rust fungus include several blueberry species (*Vaccinium*). Infection levels usually return to endemic levels in a year or so and the disease is not expected to have major ecological change.

An unusual disorder of unknown cause developed in western hemlock needles during 2001. Affected trees had numerous scattered needles turn yellowish and fall prematurely. Fruiting bodies of *P. vaccinii* were

generally not found in these cases and there must be some other cause.

Foliage Diseases of Cedars

Gymnosporangium nootkatense Arth.

Didymascella thujina (Durand) Maire

Two fungi that infect the foliage of cedar, *G. nootkatense* on yellow-cedar and *D. thujina* on western red-cedar, occurred at endemic levels this year. *G. nootkatense* was found at the very northwest limits of the natural range of yellow-cedar in Prince William Sound several years ago. *D. thujina* was the more damaging of the two fungi and was common wherever its host was found. Neither fungus resulted in severe defoliation or death of cedar trees. Homeowners sometimes complain about *D. thujina* because infection can be severe enough to alter the general appearance of ornamental red-cedar trees. Neither disease has major ecological effects.

Spruce Needle Blights

Lirula macrospora (Hartig) Darker

Lophodermium picea (Fuckel) Höhn.

Rhizosphaera pini (Corda) Maubl.

The fungus *L. macrospora* is the most important needle pathogen of spruce. In 2001 it occurred at low to moderate levels in most areas within the range of Sitka and white spruce. It was found at higher levels on individual Sitka spruce trees in young-growth stands, however. *L. picea* was present at low infection levels in 2001. This disease is more typical of larger, older trees of all spruce species in Alaska. *R. pini* continued at endemic levels after causing damage several years ago in coastal Alaska. Damage closely resembles that caused by spruce needle aphid. Microscopic observation of the tiny fruiting bodies erupting from stomata on infected needles is necessary for proper identification.

The primary impact of these needle diseases is generally one of appearance. They can cause severe discoloration or thinning of crowns but typically have only negligible ecological consequence. However, repeated heavy infections may slow the growth of spruce and benefit neighboring trees, thereby altering species composition to some degree.

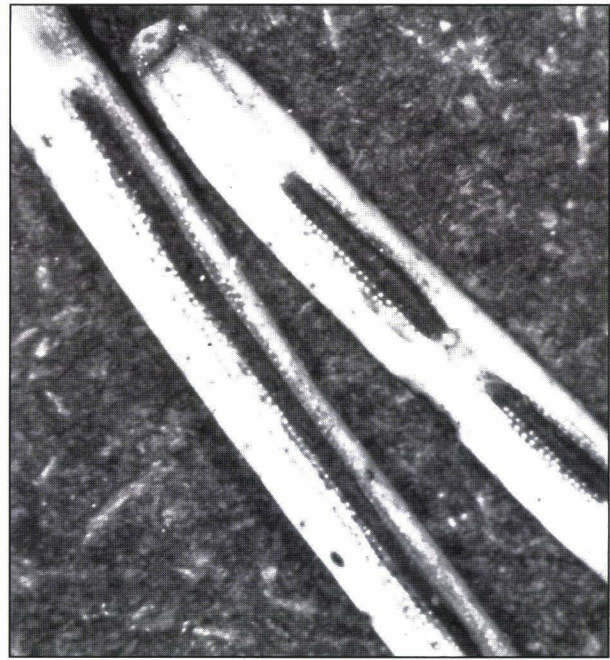


Figure 33. *Lirula macrospora* fruiting bodies on spruce needles.

Root Diseases

Three important tree root diseases occur in Alaska: tomentosus root rot, annosus root disease, and armillaria root disease. The laminated root disease caused by a form of the fungus *Phellinus weirii*, so important in some western forests of British Columbia, Washington, and Oregon, is not present in Alaska. A nonroot disease form of the fungus is present in southeast Alaska, where it causes a white rot in western red-cedar, contributing to the very high defect levels in this tree species.

Although relatively common in Alaskan forests, root diseases are often misdiagnosed or overlooked. Diagnosing root disease can be challenging because the infected tissue is primarily below ground in roots and infected trees may lack above ground symptoms. Identification of a root disease should not be made solely on the basis of crown symptoms. Above ground symptoms, such as chlorotic foliage, stress cone crop, and reduced branch growth can be caused by a wide array of stress factors other than root diseases.

Root disease pathogens affect groups of trees in progressively expanding disease centers. Typically, disease pockets contain dead trees in the center and living, but infected trees in various stages of decline, at the edges. Root disease fungi spread most efficiently from tree to tree through root contacts. Infected trees are prone to uprooting, bole breakage, and outright mortality due to the extensive decay of root systems and the lower tree bole. Volume loss attributed to root diseases can be substantial, up one third of the gross volume. In managed stands, root rot fungi are considered long-term site problems because they can remain alive and active in large roots and stumps for decades, impacting the growth and survival of susceptible host species on infected sites.

Ecologically, root diseases are considered natural, perhaps essential, parts of the forest altering stand structure, composition, and increasing plant community diversity through canopy openings and scattered mortality. Resistant tree species benefit from reduced competition within infection centers. Wildlife habitat may be enhanced by small-scale mortality centers and increased volume of large woody downed material.



Figure 34. Mushrooms of *Armillaria sinapina*.

Armillaria Root Disease

Armillaria spp.

Several species of *Armillaria* occur in the coastal forests of southeast Alaska, but in general, these species are less-aggressive, saprophytic decomposers that only kill trees when they are under some form of stress. Studies in young, managed stands indicate that *Armillaria* sp. can colonize stumps, but will not successfully attack adjacent trees.

Several species of *Armillaria* occur in south-central and interior Alaska some attack conifers while others attack hardwoods. Most species appear to be weak pathogens invading trees under some form of stress. Research is currently underway to determine the species present and their impacts in the boreal forests.

Tomentosus Root Disease

Inonotus tomentosus (Fr.) Teng.

I. tomentosus causes root and butt-rot of white, Lutz, Sitka, and black spruce. The fungus may also attack lodgepole pine and tamarack. Hardwood trees are not considered hosts. The disease appears to be widespread across the native range of spruce in south-central and interior Alaska but to date, has not been found in southeast Alaska.

Spruce trees of all ages are susceptible to infection through contact with infected roots. Infected trees exhibit growth reduction or mortality, depending on age. Younger trees may be killed outright while older trees may persist in a deteriorating condition for many

years. Studies indicate that volume loss in the butt log of older infected trees can be substantial, up one third of the gross volume. Trees with extensive root and butt decay are prone to uprooting and bole breakage. Individual mortality centers (groups of infected trees) are typically small, however, coalescing centers can occupy large areas.

Studies indicate that *I. tomentosus* will remain alive in colonized stumps for at least three decades, and successfully attack adjacent trees through root contacts. Thus, spruce seedlings planted in close proximity of infected stumps are highly susceptible to infection through contacts with infected roots. Recognition of this root disease is particularly important in managed stands where natural regeneration of white and Lutz spruce is limited and adequate restocking requires planting. The incidence of this root rot is expected to increase on infected sites that are replanted with spruce.

Tomentosus root disease can be managed in a variety of ways depending on management objectives. Options for manipulating levels of root disease on infested sites include: establishment of nonsusceptible species in root rot centers (i.e., hardwood trees), avoid planting susceptible species within close proximity of diseased stumps, and removal of diseased stumps and root systems. Pre- and post harvest walk-through surveys in managed stands can be used to stratify the area by disease incidence. Studies are currently underway to assess mortality in young growth stands and to determine site factors that influence disease incidence and severity. A volume loss study was initiated in 2001 to quantify the butt cull losses due to this root disease in Alaska.

Annosus Root & Butt Rot

Heterobasidion annosum (Fr.) Bref.

Annosus commonly causes root and butt-rot in old-growth western hemlock and Sitka spruce forests in southeast Alaska. To date, *H. annosum* has not been documented in south-central or interior Alaska.

Elsewhere in the world, spores of the fungus are known to readily infect fresh stump surfaces, such as those found in clearcuts or thinned stands. Studies in

managed stands in southeast Alaska, however, indicate limited stump infection and survival of the fungus. Thus, this disease poses minimal threat to young managed stands from stump top infection.

Reasons for the limited stump infection may be related to climate. High rainfall and low temperatures, common in Alaska's coastal forests, apparently hinder infection by spores.

Declines and Abiotic Factors

Yellow-cedar Decline

Decline and mortality of yellow-cedar persists as one of the most dramatic forest problems in Alaska. Approximately 500,000 acres of decline have been mapped during aerial detection surveys. Concentrated mortality occurs in a wide band from western Chichagof and Baranof Islands to the Ketchikan area.

All research suggests that contagious organisms are not the primary cause for this extensive mortality. Some site factor, probably associated with poorly drained anaerobic soils, appears to be responsible for initiating and continuing cedar decline. Two hypotheses have been proposed to explain the primary cause of death in yellow-cedar decline:

- ◆ Toxins are produced by decomposition in the wet, organic soils, or
- ◆ Shallow fine roots are damaged from freezing, associated with climatic warming and reduced insulating snowpack in the last century.

These hypotheses are developed in some detail (Hennon and Shaw 1994, 1997). Interestingly, considerable concentrations of newly killed trees were evident in declining forests during 1996 and 1997, perhaps a response to the unusually prolonged cold temperatures with little snowpack that persisted during the previous two winters. Whatever the primary cause of this mysterious decline, all available information indicates that it is probably a naturally occurring phenomenon. In 2001, we continued intensive monitoring soil temperature and hydrology in one area to evaluate these ideas. We also implemented more widespread soil temperature monitoring at two new sites near Peril Strait in 2001.

Research suggests that the total acreage of yellow-cedar decline has been increasing very gradually; the slow

increase in area has been a result of the expansion of existing decline (less than 3 feet per year). Most stands contain trees that died up to 100 years ago (snags still standing), as well as recently killed cedars, dying cedars (with yellow, red, or thinning crowns), healthy cedars, and other tree species.

Ground surveys show that 65 percent of the basal area of yellow-cedar is dead on this acreage. Other tree species are affected in different ways: on some sites they produce increased growth, presumably due to less competition, and on other sites they experience slowed growth and mortality due to deteriorating site conditions (poor drainage). Species change to western hemlock and mountain hemlock and large increases in understory biomass accumulation for brushy species appear to be occurring in some stands where decline has been ongoing for up to a century.

The primary ecological effect of yellow-cedar decline is to alter stand structure (i.e., addition of numerous snags) and composition (i.e., yellow-cedar diminishing and other tree species becoming more numerous) that leads to eventual succession favoring other conifer species. The creation of numerous snags is probably not particularly beneficial to cavity-using animals because yellow-cedar wood is less susceptible to decay. Region-wide, this excessive mortality of yellow-cedar may lead to diminishing populations (but not extinction) of yellow-cedar, particularly when the poor regeneration of the species is considered.

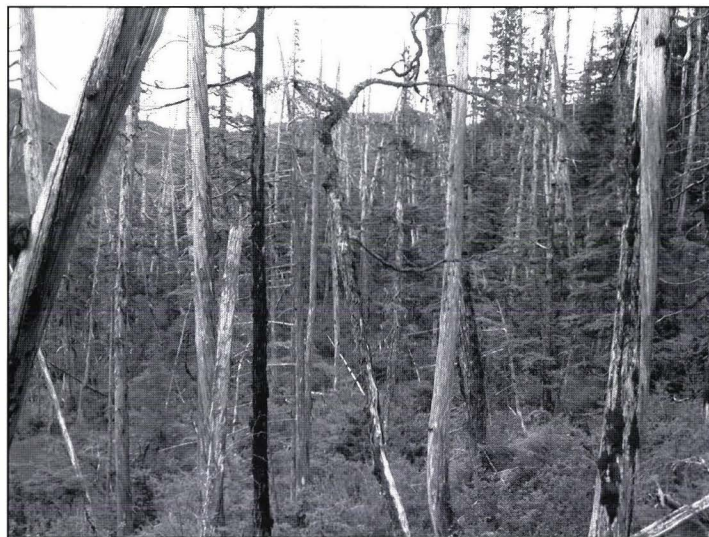


Figure 35. Yellow-cedar decline.

The large acreage of dead yellow-cedar and the high value of its wood suggest opportunities for salvage. Cooperative studies with the Wrangell Ranger District, the Forest Products Laboratory in Madison, Wisconsin, Oregon State University, and State and Private Forestry are investigating the mill-recovery and wood properties of snags of

Map 7. Cedar Decline in Southeast Alaska.

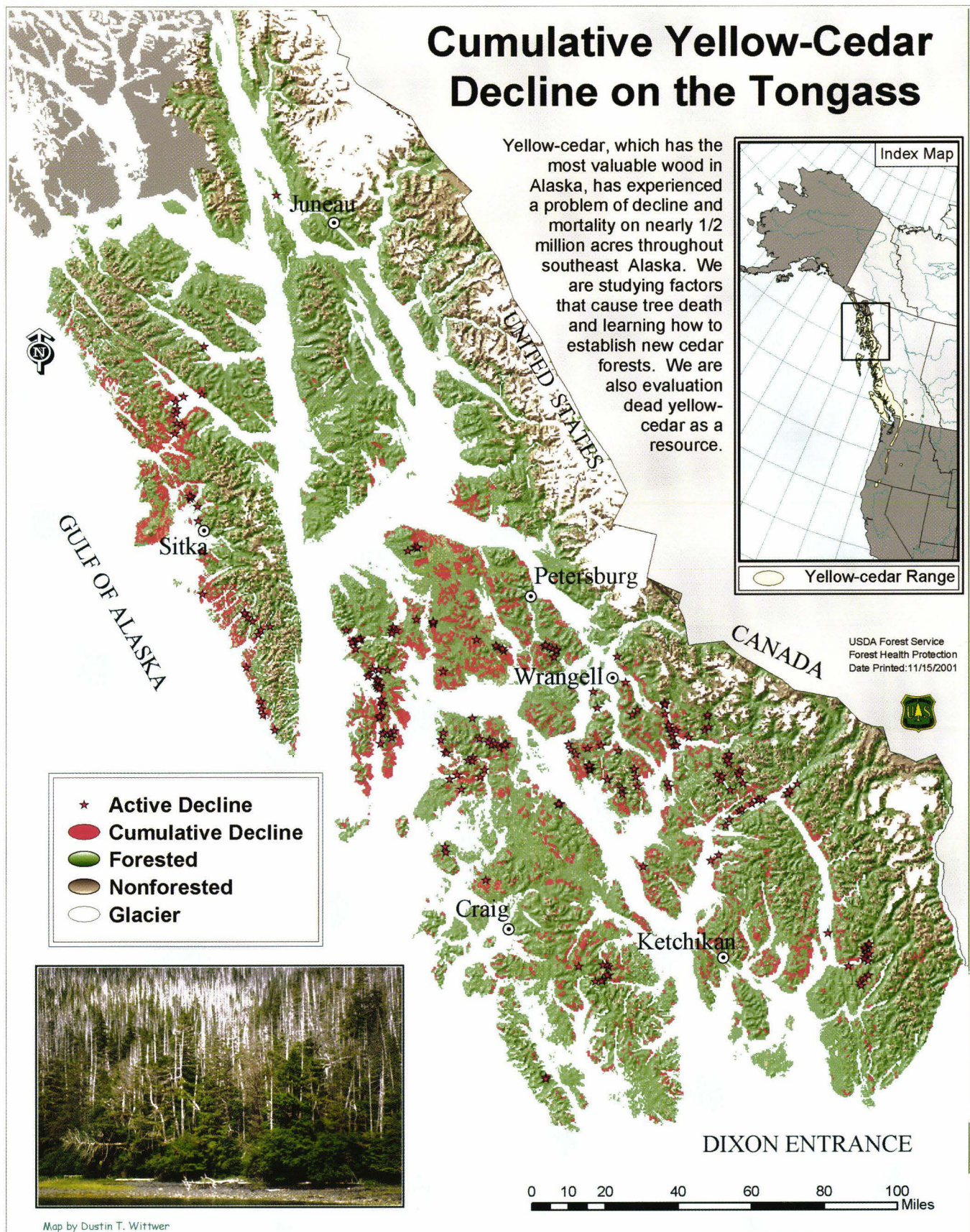


Table 5. Acreage affected by yellow-cedar decline in southeast Alaska in 2001 by ownership

National Forest	442,478	Native Land	19,497
Admiralty National Monument	5,364	Admiralty National Monument	55
Admiralty Island	5,364	Baranof Island	254
Craig Ranger District	27,046	Chichagof Island	862
Dall & Long Island	915	Dall and Long Island	1,349
Prince of Wales Island	26,131	Kruzof Island	143
Hoonah Ranger District	977	Kuiu Island	502
Chichagof Island	977	Kupreanof Island	4,280
Juneau Ranger District	827	Mainland	877
Mainland	827	Revillagigedo Island	2,285
Ketchikan Ranger District	30,981	Prince of Wales Island	8,890
Annette & Duke Islands	1,770		
Mainland	14,123	Other Federal	793
Revillagigedo & Gravina Islands	15,089	Baranof Island	355
Misty Fiords National Monument	24,630	Chichagof Island	3
Mainland	15,639	Prince of Wales Island	88
Revillagigedo Island	8,991	Etolin Island	35
Petersburg Ranger District	153,489	Kuiu Island	175
Kuiu Island	65,840	Kupreanof Island	138
Kupreanof Island	72,101		
Mainland	8,057	State and Private Land	21,738
Mitkof Island	5,177	Admiralty Island	9
Woewodski Island	2,315	Baranof & Kruzof Islands	3,398
Sitka Ranger District	109,473	Chichagof Island	1,130
Baranof Island	48,619	Dall & Long Islands	62
Chichagof Island	33,939	Gravina Island	1,353
Kruzof I	26,915	Kosciusko & Heceta Islands	155
Thorne Bay Ranger District	44,526	Kuiu Island	616
Heceta Island	893	Kupreanof & Mitkof Islands	2,714
Kosciusko Island	11,248	Northern Mainland	42
Prince of Wales Island	32,385	Central Mainland	2,656
Wrangell Ranger District	45,164	Southern Mainland	858
Etolin Island	18,481	Prince of Wales Island	3,325
Mainland	12,935	Revillagigedo Island	4,217
Woronofski Island	394	Wrangell Island	1,203
Wrangell Island	9,161		
Zarembo Island	4,192	Total Land Affected	*484,506

*Acreage by ownership was tabulated using Alaska land status data from State of Alaska, Department of Natural Resources. In prior years a different ownership layer was used to tabulate this information. Other changes in acreage figures are due to a change in the resource, refined sketch mapping or changes in GIS techniques.

yellow-cedar that have been dead for varying lengths of time. This work includes wood strength properties, durability (decay resistance), and heartwood chemistry.

Little is known about wildlife use and dependency on yellow-cedar forests. We would like to evaluate birds' use of each of the snag classes as nesting or feeding habitat. In a companion study that we have initiated, we are investigating the insect community on dead cedars; insects on recently killed trees may be an important prey source for insectivorous birds.

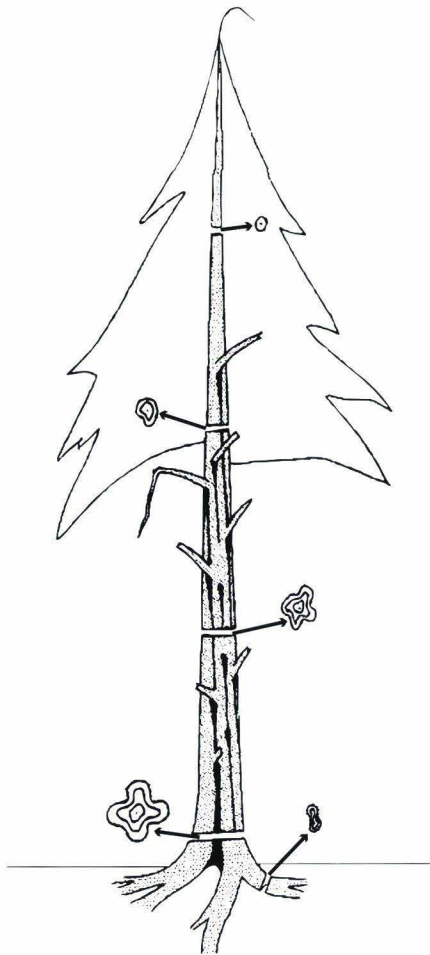


Figure 36. Hemlock fluting branches disrupt the vertical flow of carbohydrate in the stem causing annual rings to become asymmetrical. Flutes originate beneath decadent branches and extend downward, forming long grooves where other branches are intersected. (Figure and caption from Julin, K.R. and Farr, W.A. 1989. Stem Fluting of Western Hemlock in Southeast Alaska).

Water Damage

Nearly 131,612 acres of flooding were detected during the 2001 aerial surveys. Heavy rains in July coupled with run-off from the heavy snowpack of the previous winter contributed to this flooding. The majority of the flooding (115,194 acres) was observed in or near the Tetlin National Wildlife Refuge. The Nabesna, Chisana, and Tanana Rivers all contributed to the flooding. Impacts to fisheries in the numerous clear water lakes adjacent to these glacially-fed rivers may be experienced due to the infusion of large volumes of silt-laden waters from these rivers. Another large area of flooding, 12,000 acres was located along the south side of the Yukon River between the villages of Koyukuk and Galena. No current damage due to the flooding was noted, however these areas bear further observation during 2002 aerial surveys. A considerable number of white spruce stands were noted to be in standing water that may place these stands into a stressful condition that, in other areas, has contributed to increased stand susceptibility to bark beetle attack.

Winter Damage

Red alder trees in Juneau and along its road system to the north suffered from a form of winter injury in 2001. Some trees died; others had surviving buds that developed shoots and leaves late in the spring after normal bud break. The generally warm winter followed by cold temperatures in late winter and early spring are thought to be responsible for this injury.

Hemlock Fluting

Deeply incised grooves and ridges extending vertically along boles of western hemlock characterize hemlock fluting. Fluting is distinguished from other characteristics on tree boles, such as old callusing wounds and root flaring, in that fluting extends near or into the tree crown and fluted trees have more than one groove. Bole fluting is common on western hemlock in many areas of southeast Alaska. This condition reduces the value of hemlock logs because they yield less sawlog volume and bark is contained in some of the wood. The cause of fluting is not completely understood, but associated factors include: increased wind-firmness of fluted trees, shallow soils, and a triggering mechanism during growth release (e.g., some stand management treatments). The asymmetri-

cal radial growth appears to be caused by unequal distribution of carbohydrates due to the presence of dead branches. Researchers have documented the development of fluting in young hemlock stands that regenerated following clearcut harvesting or other disturbance. After several centuries, fluting sometimes is no longer outwardly visible in trees because branch scars have healed over and fluting patterns have been engulfed within the stem.

Bole fluting has important economic impact, but may have little ecological consequence beyond adding to wind firmness. The deep folds on fluted stems of western hemlock may be important habitat for some arthropods and the birds that feed upon them (e.g., winter wren).

Status of Animal Damage

Moose

Alces alces

At many locations across south-central and interior Alaska moose damage hardwoods by repeatedly browsing stems and wounding tree boles. Heavy, repeated browsing on the bole of live trees, particularly aspen and willow, results in broken branches, wounds, and stunted malformed stems. Wood decay fungi are known to invade trunk wounds caused by moose.

Snowshoe Hare

Lepus americanus

Bole wounds, terminal and lateral bud damage, and seedling mortality were attributed to browsing by snowshoe hares on hardwoods and conifers in the interior this year. Studies indicate that stem decay fungi utilize dead branches (killed by hare browsing) as infection courts but bole wounds lack decay. Pronounced resin flow at the wounds and winter desiccation of the wound surface likely contribute to the lack of decay associated with bole wounds caused by hares.

Old damage to mature trees and new damage to seedlings was evident in surveys of pre-commercially thinned white spruce stands near Tok. Years ago, hare browsing killed the main stem; the characteristic angled browse mark is still evident on the dead leader. Live mature trees retain the dead leader but have a pronounced stem crook at the point where a lateral branch became dominant following leader death. The dead leaders provided an infection court for heart rot decay by *Phellinus chrysoloma*. New terminal and lateral bud browsing was evident on white spruce, paper birch, and aspen seedlings across the

interior. Recovery potential of trees following severe browsing is not known.

Porcupine

Erethizon dorsatum

Porcupines cause severe damage to Sitka spruce and western hemlock trees in numerous local areas of southeast Alaska. An extensive survey has documented the level of porcupine damage in young-growth stands. Feeding injuries to trees are confined to the known distribution of porcupine. Damage is especially serious on Mitkof Island in southeast Alaska. Other damage has been noted at Thomas Bay, Cleveland Peninsula, Bradfield Canal, Anita Bay and other areas of Etolin Island, Douglas Island, and the Juneau area.

In 2001, we found that porcupines cause very frequent bole wounding on small to medium sized sub-alpine fir trees near Skagway. Porcupines also damage trees throughout interior Alaska. Bark beetles, including *Ips* spp., have been found infesting the damaged trees.

In southeast Alaska, the feeding behavior of porcupines change as forests develop and trees become larger and older. Porcupines climb smaller trees and kill or cause top-kill by removing bark along the entire bole, or the bole near the top of the tree. As trees become larger, around 40-50 years old, most of the damage is in the form of basal wounding. Most of these larger trees are not killed, but the large basal scars allow fungi to enter the bole and begin to cause wood decay.

The primary ecological consequences of porcupine feeding are: (1) to provide greater diversity of structure and vegetation in young, even-aged conifer stands through mortality and (2) to provide greater



Figure 37. Recent brown bear scar on a yellow-cedar tree.

levels of heart rot decay by wounding older trees. This latter effect can alter mortality patterns in old forests as trees may often die through bole breakage.

Bear

Ursus arctos

Ursus americanus

Yellow-cedar trees were wounded in the spring by brown bears on Baranof and Chichagof Islands. Brown bears rip the bark away from the lower boles of these trees, apparently to lick the sweet cambium. The majority of yellow-cedar trees in some stands have basal wounds from bear feeding. Other tree species in southeast Alaska are unaffected. Black bears caused injury to the lower boles of white and Lutz spruce and occasionally aspen in the lowland forests of the Kenai Peninsula. Trees with old scars may have associated columns of wood decay.

Appendices

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Integrated Pest Management

Integrated pest management (IPM) has been described as a “systems approach to alter pest damage to acceptable levels through a variety of techniques, including predators and parasites, genetically resistant hosts, natural environmental modifications, and when necessary and appropriate, chemical pesticides.” Current IPM activities in Region 10 include:

- ◆ Participation in a cooperative effort with the Alaska Cooperative Extension Service (ACE) to provide pest management information to Alaska residents. The program, which completed its twenty-first season, includes education, research and survey activities, also provides integrated pest management information concerning urban forestry as well as garden and greenhouse pests. The program is educational in nature and provides the public with a means to learn about pest management in an informal and accessible manner. In 2001, IPM Technicians were located in Fairbanks, Delta, Palmer, Anchorage, Soldotna, and Juneau. The Anchorage office had two seasonal technicians and one full-time Program Coordinator; the remaining locations had one seasonal IPM Technician from May through the end of September. The total recorded client contacts reached more than 7,700. Technicians conducted more than 3,200 educational contacts including workshops, more than 50 media contacts (newspaper articles, television and radio “spots”), more than 500 site visits, and more than 2,200 clients assisted via phone calls and walk-in requests. More than 50 percent of the IPM Technician activities occurred in the Anchorage Bowl; home to over 40 percent of the state population.
- ◆ Verbenone has been shown to significantly reduce *Ips perturbatus* attraction to baited funnel traps. Verbenone bubble caps were tested in 2001 to deter *Ips* attacks on uninfested white spruce bolts both on the Kenai Peninsula and in Interior Alaska. Within a week of bubble cap placement, however, all bolts were heavily infested. A study was initiated to determine temperature differences between: interior of white and black-color funnel traps; cortical temperatures of spruce tree boles and horizontal spruce bolts lying on the ground. June temperatures were analyzed between noon and 5 p.m., common time for bark beetle dispersal. This was replicated in a sunny location and a shaded forest setting. Results from the sunny location showed little differences in average hourly temperatures between white traps (71.5° F), black traps (67.4° F), and tree boles (66.5° F). The horizontal spruce bolts, however, had a mean temperature of 81.3° F with a maximum temperature of 130.5° F and 35 hourly readings above 100° F. Temperatures from the shaded site showed the same trends although with lower temperatures. Elution rates of bubble caps are standardized at approximately 75° F. The lack of treatment effect with the use of verbenone bubble caps stapled to uninfested spruce bolts were probably due to the quick reduction of verbenone in the bubble caps due to high temperatures.
- ◆ The genetics of spruce aphid infestation will be studied in southeast Alaska by doing “fingerprint” analysis of separated populations across coastal Alaska. Lincoln University, Canterbury, Australia, Karen Armstrong’s lab will help do the chemical analysis.
- ◆ An option available for treating trees with a spruce aphid infestation involves injecting the infested tree with a systemic insecticide called acephate. Since bole drilling is needed to apply the acephate using Acecaps, multiple year treatments may be problematic in terms of damage caused to the tree. Soil injection techniques with the same chemical will be almost as safe for other organisms; with the exception of maybe some soil microbes and annelids at the site of injection. Soil injection tests will be conducted in collaboration with the Juneau Ranger District of the Forest Service.
- ◆ The pine engraver, *Ips pini*, is being studied from southeast Alaska by University of Minnesota to describe the ratios and biochemical structures of pheromones used by these beetle to aggregate in trees. Some trees were baited with the eastern North America pheromone mix of the attractant while other trees were baited with the western North America pheromone mix. Infested logs were then sent to University of Minnesota for analysis.

- ◆ Yellow-cedar wood is often devalued because of dark staining. Some evidence suggests that insects are involved in introducing a dark-staining fungus. Wood boring insect tunnels of the wood wasp was found in association with the dark stained areas. Since these wood wasps are believed to have only a one-year life cycle, many of them can be reared from infested logs and isolations can be made from the sac at the base of the ovipositor (of the females). It can then be determined if dark-stain fungi are being inoculated into trees at the time of egg laying. Wood wasps in other tree species are known to introduce decay fungi. Isolations revealed *Sporidesmium* sp. and *Phialophora melinii* as two of the most common dark fungi.
- ◆ Dead yellow-cedar has been sketch-mapped on more than 500,000 acres and is becoming more important as a resource. Understanding the spatial context of the decline is important to understanding potential causes and how to manage the resource. Efforts are currently underway to develop detection and mapping techniques beyond the current sketch mapping method. Several ways of obtaining this information are being explored, using image analysis of various image types and scales and GIS analysis. The test results will be checked using the existing GIS cedar decline layer, existing inventory or plot data, and ground truth plots installed in 2001.
- ◆ The spread and intensification of hemlock dwarf mistletoe is currently under study in even-aged stands, stands that have received different selective harvest treatments, and stands that experienced extensive wind damage in the 1880s. Plots within these stands have been used to quantify the short, medium, and long-term effects of the disease under different selective harvesting strategies. Results show a substantial difference by stand management. Impact of the disease is light to absent in later developmental stages of even-aged forests but can be severe in forests under some forms of selective harvesting. This indicates a wide range of disease severity that can be related to simple measures of inoculum load at the time of harvest. Distances and intensities of spread are being determined to provide information so that managers can design appropriate harvesting scenarios in relation to expected disease levels. The influence of the disease on tree growth and mortality is also under investigation.

Submitting Insects and Diseases for Identification

The following procedures for the collection and shipment of specimens should be used for submitting samples to specialists:

I. Specimen collection:

1. Adequate material should be collected
2. Adequate information should be noted, including the following:
 - a. Location of collection
 - b. Date of collection
 - c. Who collected the specimen
 - d. Host description (species, age, condition, # of affected plants)
 - e. Description of area (e.g., old or young forest, bog, urban);
 - f. Unusual conditions (e.g., frost, poor soil drainage, misapplication of fertilizers or pesticides?).
3. Personal opinion of the cause of the problem is very helpful.

II. Shipment of specimens:

1. General: Pack specimens in such a manner to protect against breakage.
2. Insects: If sent through the mail, pack so that they withstand rough treatment.
 - a. Larvae and other soft-bodied insects should be shipped in small screw-top vials or bottles containing at least 70 percent isopropyl (rubbing) alcohol and 30 percent water. Make certain the bottles are sealed well. Include in each vial adequate information, or a code, relating the sample to the written description and information. Labels inserted in the vial should be written on with pencil or India ink. Do not use a ballpoint pen, as the ink is not permanent.
 - b. Pupae and hard-bodied insects may be shipped either in alcohol or in small boxes. Specimens should be placed between layers of tissue paper in the shipping boxes. Pack carefully and make certain that there is very little movement of material within the box. Do not pack insects in cotton.
3. Needle or foliage diseases: Do not ship in plastic bags. Sprinkle lightly with water before wrapping in newspaper. Pack carefully and make sure that there is very little movement of material within the box. Include the above collection information. For spruce and other conifers, include a description of whether current year's-needles, last-year's needles, or old-needles are attacked.
4. Mushrooms and conks (bracket fungi): Do not ship in plastic bags. Either pack and ship immediately, or first air dry and then pack. To pack, wrap specimens in dry newspaper and pack into a shipping box with more newspaper. If on wood, include some of the decayed wood. Be sure to include all collection information.

III. Shipping:

1. Ship as quickly as possible, especially if specimens are fresh and not air-dried. If samples cannot be shipped rapidly, then store in a refrigerator.
2. Include return address inside shipping box.
3. Mark on outside: "Fragile: Insect-disease specimens enclosed. For scientific purposes only. No commercial value."

Biological Evaluations, Technical Reports, and Publications

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Alaska Ecoregion Descriptions

The ecoregions of Alaska and neighboring territories are briefly described below. These descriptions are abbreviated versions of those given by Nowacki and all (2000). They reflect the results of an interagency effort to unify the designations given in Gallant and all (1995) and Nowacki and Brock (1995). Climate, surficial geology, and vegetation communities are described in a triarchical format.

Polar

Arctic Tundra: These open, wind-swept lands are gripped by polar conditions year around. Temperatures fluctuate substantially among seasons, though always cold. Mean monthly temperatures in the summer generally do not surpass 10°C—a threshold that approximately delimits tree growth. The cold is reinforced by sea-ice that hugs the shorelines over much of the year. The severe atmospheric cold limits water-holding capacity, thus depriving this area of precipitation (less than 50 cm per year). Even so, surfaces are often moist or wet due to thick permafrost that impedes drainage. These high-latitude areas are covered by tundra dominated by tussock sedges, mosses and low shrubs.

Beaufort Coastal Plain (P9): This treeless, wind-swept plain gradually ascends from the Arctic Ocean to the foothills of the Brooks Range. Unconsolidated deposits of marine, fluvial, and glacial origin overlay thick layers of continuous permafrost. There is a lack of bedrock control so the physiography is flat. The moist and wet sedge tussock tundra is comprised mainly of sedges, herbs, and mosses. Low shrubs occur mostly in small drainages where micro topography allows deeper rooting.

Brooks Foothills (P1): These dissected hills and ridges form the northern flank of the rugged Brooks Range as it descends toward the Beaufort Coastal Plain. Thick continuous permafrost and displays ice-related features such as pingos, solifluction lobes, ice-wedge polyons, and stone stripes underlie the surface. Soils in the active permafrost layer are fairly wet. Moist tussock sedge tundra spans across the landscape interspersed with willow communities along river corridors.

Brooks Range (P3): This rugged, east-west trending range represents the northern extension of the Rocky Mountains. The dry polar climate coupled with underlying permafrost make growing conditions difficult for plant life, particularly at high elevations or on steep slopes with active scree movement. Alpine, moist, and tussock tundra of lichens, sedges, and ericaceous plants exist where conditions permit (lower summits and mountainsides). The arctic tree line enters larger drainages along the south portion of the Brooks Range. Here, taller shrub communities fringe these forested valleys.

Bering Tundra: These wind-swept lands occur in and adjacent to the Bering Sea. Here, the sea influences the polar climate only a limited extent (slight temperature moderation and increase in summer precipitation) because of its inherent coldness and long presence of sea ice during the year. With sea ice descends a common Arctic denizen, the polar bear, into the northern reaches of the Bering Sea. Temperatures are cold year around allowing, for the most part, only low growing tundra vegetation to grow. Scattered patches of spruce occur along rivers in the eastern portion of the region.

Kotzebue Sound Lowlands (P5): Shaped by past sea-level fluctuations, the land was once connected to Siberia and formed a part of a large unglaciated area called Beringia during glacial periods when water was locked in continental ice sheets and sea levels were low. Today, this flat plain of marine sediments, deltas, and low-lying glacial till is limited to a rim of lowlands surrounding the Kotzebue Sound. A thick loess blanket blown off nearby outwash plains during glacial periods covers much of the area. Thawing permafrost is widespread, creating a thaw-lake cycle that forms a diverse mosaic of wetlands including marshes, wet meadows, riparian shrublands, and intervening ridges with tussock tundra as lakes form and drain, and ground ice aggrades in the exposed sediments.

Seward Peninsula (P4): This cold, wind-swept landmass jutting out into the Bering Sea represents the southernmost haunt of polar bears on mainland Alaska. Sedimentary, metamorphic, and volcanic rocks

intertwine to form a landscape mosaic of coastal lowlands, expansive convex hills with scattered broad valleys, and small, isolated groups of rugged mountains. Vegetation is principally tundra, with alpine Dryas-lichen tundra and barrens at high elevations and moist sedge-tussock tundra at lower elevations. Patches of low-growing ericaceous and willow-birch shrubs occur on better-drained areas. Scattered spruce occurs along river drainages on the extreme eastern edge of the region. Permafrost is continuous but oscillates from thin to moderately thick. Soils are often wet, shallow, and organic due to permafrost.

Bering Sea Islands (P7): These treeless rocky volcanic islands are scattered throughout shallow portions of the Bering Sea. Here, a peculiar mix of polar and maritime climates exists dependent on season. Thin to moderately thick permafrost underlies mainly thin, rocky soils. Rocky cliffs and shorelines surround moist tundra communities of sedges, grasses, low shrubs and lichens.

Bering Taiga: These open coastal areas bordering the Bering Sea are dominated by cold, seasonally moist, subpolar conditions. During the summer, moisture is derived from the adjacent Bering Sea and carried on land by the prevailing westerly. Summers are sufficiently long and warm enough to allow patches of stunted trees (i.e., taiga) to grow primarily along rivers and streams. However, summer warming is tempered by the cold prevailing winds off the Bering Sea.

Nulato Hills (P2): These low-rolling hills are the remains of an ancient mountain range after extended periods of down cutting, weathering, and erosion. East of Norton Sound, these hills ripple inland in a southwest-northeast orientation with streams flowing in intervening valleys. Vegetation patterns generally follow the terrain, with alpine Dryas-lichen tundra and moist sedge-tussock tundra on hilltops grading into short then tall willow-birch-alder shrublands and eventually spruce woodlands at progressively lower elevations. Permafrost is continuous but oscillates from thin to moderately thick.

Yukon-Kuskokwim Delta (P8): The Yukon and Kuskokwim rivers nourish this vast marshy plain as they fan out to meet the Bering Sea. Marine sediments and alluvium principally underlie this flat, lake-studded lowland. Isolated basalt hills and volcanic cinder cones jut up in places. Moderately thick to thin permafrost underlies wet and shallow organic soils. Many low-gradient streams meander dynamically across the surface. Moist tundra communities of sedge, herbs, grasses and lichens predominate with shrubs and scattered trees occurring near rivers and on hills.

Ahklun Mountains (P10): This coastal group of rugged steep-walled mountains spans two expansive wetland complexes (Yukon-Kuskokwim Delta and Bristol Bay Lowlands) along the southern Bering Sea. Here, mountain glaciers coalesced during the Pleistocene ice age and carved many broad U-shaped valleys. On the south side of the mountains, these valleys have subsequently filled with water forming large “finger” lakes. Dwarf shrub-lichen tundra dominates mountain crests and upper slopes where permafrost is discontinuous. Shrubs (willows, birches, and alders) become progressively more abundant and robust at lower elevations as permafrost becomes more fragmented. In valleys, shrublands are punctuated by sedge-tussock tundra meadows and mixed forests.

Bristol Bay Lowlands (P6): This flat to gently rolling lowland is comprised mainly of glacial till and outwash deposited by various Pleistocene glaciers from the surrounding Ahklun Mountains and Aleutian Range. This basin is underlain with mixes of glacial, alluvial, and marine sediments all cloaked with varying amounts of loess. Permafrost occurs in scattered isolated masses. Wet organic soils support low and dwarf shrub communities of willow, birch, and alder. Mosses and lichens are abundant groundcovers.

Boreal

Intermontane Boreal: These areas experience extreme seasonal temperature changes from long, cold winters to short moderately warm summers. Boreal woodlands and forests cover much of this undulating landscape. The continental climate is fairly dry throughout the year and forest fires rage during summer droughts. This intermontane terrain sandwiched between the Brooks and Alaska Ranges remained largely ice-free during the last ice age, forming part of the “Beringia Corridor.”

Kobuk Ridges and Valleys (B12): A series of paralleling ridges and valleys radiate southwards from the Brooks Ranges. Permafrost of thin to moderate thickness underlies most of the area. Forests and woodlands dominate much of valley bottoms and mountainsides with black spruce in wetland bogs, white spruce and balsam poplar along rivers, and white spruce, birch, and aspen on well-drained uplands. Tall and short shrublands of willow, birch, and alder communities occur in ridges. Trees become increasingly sparse, less robust, and restricted to lower elevations in the west—here forest succession is slowly progressing along rivers (e.g., lower Noatak River).

Ray Mountains (B2): The Ray Mountains are an overlapping series of compact, east-west trending ranges underlain by Ruby terrane. The metamorphic bedrock is usually covered with rubble and soils are subsequently shallow and rocky. Permafrost is generally discontinuous and ranges from thin to moderate thickness. Open scrubby forests of spruce and aspen interspersed with tall shrublands prevail over much of the area. Low shrubs and alpine tundra progressively dominate at higher elevations. Forest fires are common in the summer.

Davidson Mountains (B14): Along the south flank of the eastern Brooks Range lie rugged mountains dissected by broad flood plains of glacial origin. The mountains are draped by coarse rubble whereas river valleys and flood plains are lined with unconsolidated glacial and alluvial sediments. Continuous permafrost from thin to moderate thickness underlies most of the area. Boreal forests cover much of the terrain with black spruce in bogs, white spruce and balsam poplar along rivers, and white spruce, birch and aspen on uplands. Tall willow, birch, and alder communities also occur. Forest fires are frequent.

Yukon-Old Crow Basin (B6): This gently sloping basin along the Porcupine River is comprised of terraces, hilly moraines, and mountain toe slopes that ring the Yukon and Old Crow Flats. The marshy flats have developed in deep alluvial and glaciolacustrine deposits underlain by discontinuous permafrost. The poorly drained flats and terraces harbor vast wetlands pockmarked with dense concentrations of thaw lakes and ponds. Opaque with glacial silts and shoreline mud, the Yukon River forms an aquatic maze of islands, sandbars, and back sloughs as it crisscrosses the lower flats. Vegetation varies with soil drainage grading from wet grass marshes and low shrub swamps to open black spruce forests to closed spruce-aspen-birch forests on better-drained uplands. Summer forest fires are common.

North Ogilvie Mountains (B15): This terrain consists of flat-topped hills and eroded remnants of a former plain. Sedimentary rocks, especially limestone, underlie most of the area. Shallow soils have developed in rocky colluvium on mountainsides where landslides, debris flows, and soil creep frequently occur. On lower slopes, soils are deeper, moister, and underlain by extensive permafrost. Low shrub tundra of willow, alder, and birch and aspen and spruce woodlands occur at lower elevations. These mountains are the source of many streams that eventually feed the Porcupine, Yukon, and Peel Rivers. Lakes are relatively rare.

Yukon-Tanana Uplands (B13): These dissected mountains are of moderate height. The topography of smooth-topped ridges deeply incised by narrow valleys is indicative of a lack of glaciation in the past. Permafrost is discontinuous but widespread, and is particularly abundant on moist lower slopes and valley bottoms. This area straddles tree line with vegetation ranging from alpine tundra on ridges and upper slopes to boreal forests on lower slopes and valleys. Stunted black spruce woodlands occur on cold, north facing slopes whereas mixed forests (spruce, aspen, birch, poplar) occur on warm south-facing slopes. This area includes the highest incidence of lightening strikes in the Yukon and forest fires are consequently frequent.

Tanana-Kuskokwim Lowlands (B10): This alluvial plain slopes gently northward from the Alaska Range. Streams flowing across this north-sloping plain ultimately drain into one of two large river systems—the Tanana or Kuskokwim. Even though a rain shadow exists due to the neighboring Alaska Range, surface moisture is rather abundant due to the gentle topography and poor soil drainage due to underlying permafrost. Boreal forests dominate the landscape with black spruce in bogs, white spruce and balsam poplar along rivers, and white spruce, birch, and aspen on hills. Tall willow, birch, and alder communities are scattered throughout.

Yukon River Lowlands (B7): An expansive wetland system occurs along major rivers coursing through central Alaska. Deep deposits of undifferentiated sediments underlie these flood plains, lowlands, and intervening hills. Surface moisture is abundant due to the gentle grade, poor soil drainage, and presence of permafrost.

Boreal forests dominate the landscape with black spruce in bogs, white spruce and balsam poplar along rivers, and white spruce, birch, and aspen on hills. Tall willow, birch, and alder communities are scattered throughout. Many flat organic surfaces are pockmarked with dense concentrations of lakes and ponds. This unit is distinguished from the Tanana-Kuskokwim Lowlands by having lower elevations, a slightly wetter climate, and more robust vegetation.

Kuskokwim Mountains (B11): This subdued terrain is comprised of old, low-rolling mountains that have eroded down largely without the aid of recent past glaciations. Mountains are composed of eroded bedrock and rubble whereas intervening valleys and lowlands are comprised of undifferentiated sediments. Thin to moderately thick permafrost underlies most of the area. Boreal forests dominate grading from white spruce, birch, and aspen on uplands to black spruce and tamarack in lowlands. Tall willow, birch, and alder shrub communities are scattered throughout, particularly where forest fires burned in the recent past. Rivers meander through this undulating landscape following fault lines and highly eroded bedrock seams.

Alaska Range Transition: Boreal forests occur within the basins and troughs fringed by the Alaska Range. This area is considered transitional since some climatic moderation is afforded by the nearby Pacific Ocean (i.e., maritime moisture). Ice sheets heavily scoured this area during the last glaciation and small ice caps and glaciers still exist at high elevations.

Lime Hills (B4): The Lime Hills are glacially dissected mountains descending from the west side of the Alaska Range. The ridges and mountainsides are covered with colluvial rubble whereas the valleys contain glacial moraines and outwash with some alluvial deposits along rivers. The continental climate is moderated somewhat by maritime influences of the Bering Sea and North Pacific Ocean. The area is underlain by isolated masses of permafrost. Vegetation is predominately tall and low shrub community of willow, birch, and alder. Spruce forests and woodlands confined to valley bottoms and mountain toe slopes.

Alaska Range (B3): A series of accreted terranes conveyed from the Pacific Ocean have fused to form this arcing mountain range. Landslides and avalanches frequently sweep the steep, scree-lined slopes. Discontinuous permafrost underlies shallow and rocky soils. Because of its height, a cold continental climate prevails and much of the area is barren of vegetation. Occasional streams of Pacific moisture are intercepted by the highest mountains and help feed small ice fields and glaciers. Alpine tundra occurs on mid and upper slopes. Shrub communities of willow, birch, and alder occupy lower slopes and valley bottoms. Forests are relegated to the low-elevation drainages.

Cook Inlet Basin (B5): This gently sloping lowland has been buried by ice and flooded by proglacial lakes several times during the Pleistocene. As such, the basin is comprised of fine-textured lacustrine deposits ringed by coarse-textured glacial tills and outwash. Numerous lakes, ponds, and wetlands occur. The basin is generally free of permafrost. A mix of maritime and continental climates prevails with moderate fluctuations of seasonal temperature and abundant precipitation. This climate coupled with the flat to gently sloping, fine-texture surfaces give rise to wet, organic soils clothed with black spruce forests and woodlands. Ericaceous shrubs are dominant in open bogs. Mixed forests of white and Sitka spruce, aspen and birch occur on better-drained sites and grade into tall shrub communities of willow and alder on slopes along the periphery of the basin.

Copper River Basin (B8): This mountain basin lies within the former bed of Glacial Lake Ahtna on fine-textured lacustrine deposits ringed by coarse glacial tills. The basin is a large wetland complex underlain by thin to moderately thick permafrost and pockmarked with thaw lakes and ponds. A mix of low shrubs and black spruce forests and woodlands clothe the wet organic soils. Cottonwood, willow, and alder line rivers and streams as they braid or meander across the basin. Spring floods are common along drainages. The climate is strongly continental, with steep seasonal temperature variation. The basin acts as a cold-air sink and winter temperatures can get bitterly cold.

Coast Mountains Transition: The high mountains on the interior-side of the Coast Mountains are exposed to a peculiar mix of climates. Because of their sheer height, these mountains capture ocean-derived moisture as it passes inland. Yet, due to their proximity to the Interior, these mountains possess a fair degree of seasonal temperature

change similar to a continental climate. Climatic influences change with elevation, with maritime conditions on mountaintops (feeding ice caps and glaciers) grading to continental conditions at their base (boreal forests).

Wrangell Mountains (B9): This volcanic cluster of towering, ice-clad mountains occur at the northwest edge of the St. Elias Mountains. The Wrangell Mountains possess a peculiar mix of climates because of their size and geographic location (i.e., on the Interior-side of the Coastal Mountains). The abundant maritime snows feed extensive ice fields and glaciers interspersed by dull gray ridges draped with rock shard slopes and patches of alpine meadows. The climate grades to a dry continental at lower elevations where the Wrangell Mountains abut the cold-air basin of the Copper River. Shrublands of willow and alder with scattered spruce woodlands ring the lower slopes. Spruce and cottonwood occur along larger drainages. The Wrangell Mountains are highly dynamic due to active volcanism, avalanches, landslides, and stream erosion. Soils are thin and stony and underlain by discontinuous permafrost.

Kluane Range (B1): The Kluane Range encompasses the drier interior portion of the St. Elias Mountains spanning from the ablation zone (area where glacial ice melts faster than it accumulates) eastward to a fault line scarp along the Shakhwak Valley. The area has a dry continental climate. It lies within a partial rain shadow of the St. Elias Mountains whereby moisture from the Pacific Ocean is effectively rung-out of the atmosphere on its ascent over these towering peaks. The high-relief topography has been exposed to mass wasting, stream erosion and glacial scouring. Swift streams cascade down steep mountainsides where scree movement, rock falls, landslides, and soil creep actively occur. Permafrost is discontinuous. Vegetation is comprised principally of alpine tundra and barrens of lichens, prostrate willows, and ericaceous shrubs. Taller shrub communities occur at mid elevations. White spruce is found on lower slopes and valleys along the eastern boundary.

Maritime

Aleutian Meadows: This peninsula and associated island arc divides the cold and stormy water bodies of the North Pacific Ocean and Bering Sea. Harsh weather conditions prevail over these exposed landscapes including high winds, persistent clouds, rain and fog, and salt spray. This volcanic arc, built along the Pacific Plate Subduction Zone, is one of the most seismically active in the world. The vegetation is comprised mainly of shrub and herbaceous plants that can tolerate the stressful growing conditions.

Alaska Peninsula (M7): The Aleutian Range serves as the spine of this peninsula that divides Bristol Bay from the North Pacific Ocean. The folded and faulted sandstone bedrock is dotted with symmetrical cinder cones clad with ice, pumice, and volcanic ash. Earthquakes are common and some of the most active volcanoes on the continent occur here. The Pleistocene Glaciation has produced strongly contrasting topographies along this peninsula with smooth glacial moraines and colluvial shields on the north side and rugged deeply cut fjord lands on the south side. Dominant vegetation is low shrublands of willow, birch, and alder interspersed with ericaceous/heath and Dryas-lichen communities. Alpine tundra and glaciers occur on mountaintops. Spruce forests occur along the shores at the mouth of Cook Inlet and within the northern reaches of this region.

Aleutian Islands (M1): These fog-shrouded islands represent volcanic summits of a submarine ridge extending from the Alaska Peninsula to the Kamchatka Peninsula. It is one of the most seismically and volcanically active areas in the world. These islands are free of permafrost, covered by volcanic-ash soils, and dissected radially by short, swift streams. Terrestrial warming is subdued by incessant cold ocean winds and perpetual overcast clouds and fog, which limit solar insolation. The flora is a blend of species from two continents, grading from North American to Asian affinities from east to west. Mountain flanks and coastlines dominated by low shrubs of willow, birch, and alder interspersed with ericaceous-heath, Dryas-lichen, and grass communities. Alpine tundra and glaciers occur on mountains.

Coastal Rainforests: These coastal areas adjacent to the North Pacific Ocean receive copious amounts of precipitation throughout the year. Seasonal temperature changes are limited due to proximity to open ocean. A cool, hyper maritime climate dominates with minor seasonal temperature variation and extended periods of overcast clouds, fog, and precipitation. These areas warm sufficiently in the summer to allow trees to grow and dominate at lower elevations. Massive ice fields and glaciers are common in the mountains.

Alexander Archipelago (M4): This island-rich fjord land formed when the glacier-carved landscape filled with seawater after deglaciation. Rounded mountains with rolling till plains occur where continental glaciers overrode the land whereas angular mountains exist where continental glaciers did not. Glacial rebound has raised marine terraces where rich coastal lowlands and estuaries now exist. Winter snow, though abundant in locations, is ephemeral at sea level. Lush, lichen-draped temperate rain forests of hemlock and spruce blanket the shorelines and mountain slopes where soil drainage affords. Open and forested wetlands occur on poorly drained soils especially on compact glacial tills, marine terraces, and gentle slopes. On upper slopes, forests progressively give way to shrublands, landslide and avalanche tracks, and alpine tundra.

Boundary Ranges (M2): A northwest-southeast trending batholith of resistant granite and granodiorite underlies this portion of the Coast Mountains. Abundant maritime snows feed huge ice fields and glaciers that form an undulating matrix around exposed, rugged peaks called nunataks. Summer meltwaters accumulate and flow across these ice fields and glaciers, often plunging into deep, icy crevasses called moulins. The southernmost extent of tidewater glaciers on the North American continent occurs here. Only a few large rivers (Taku and Stikine Rivers) manage to breach this mountain range from the Interior. These, together with smaller streams, support large salmon runs of all five Pacific species. Alpine tundra habitats consist of sedges, grasses, and low shrubs.

Chugach-St. Elias Mountains (M6): Arcing terranes of Pacific origin have been thrust onto the North American continent forming a rugged ice-clad mountain chain that surrounds the Gulf of Alaska. This is the largest collection of ice fields and glaciers found on the globe outside the polar region. The sheer height of these mountains together with their expansive ice fields forms an effective barrier for Interior species except along the Alsek and Copper River corridors. Thin and rocky soils exist where mountain summits and slopes are devoid of ice, snow, and active scree. Here, alpine communities of sedges, grasses, and low shrubs grow. Deeper soils have formed in unconsolidated moraine and fluvial deposits underlain by isolated pockets of permafrost in broad u-shaped valleys. Alder shrublands and mixed forests occur on lower slopes and valley floors.

Gulf of Alaska Coast (M5): The northern shorelines and adjacent mountain slopes along the Gulf of Alaska form this region. A fjordal coastline and archipelago exists around Prince William Sound and points west where continental ice sheets repeatedly descended in the past. A coastal foreland extends from the Copper River Delta southeast to Icy Point fringed by the slopes and glacier margins of the Chugach-St. Elias Mountains. Here, unconsolidated glacial, alluvial, and marine deposits have been uplifted by tectonics and isostatic rebound to form this relatively flat plain. Snow is abundant in the winter and persists for long periods at sea level. Permafrost is absent. Lush, lichen-draped temperate rain forests of hemlock and spruce occur where soil drainage occurs, interspersed with open wetlands.

Kodiak Island (M3): This rugged, fjord-carved island complex is a geologic extension of the Chugach Mountains with a similar suite of folded and faulted sedimentary rocks of Pacific origin. During past glaciations, a solid ice sheet spanned Shelikof Strait connecting this group of islands with the mainland. Today, high sharp peaks with cirque glaciers and low rounded ridges overtop glacially scoured valleys covered with till or lacustrine deposits. The flora of island group is still recovering from the last glaciation. For instance, trees did not survive the last Pleistocene glaciation and only recently has Sitka spruce and black cottonwood managed to regain a foothold on the northeastern portion of this island group. At present, luxuriant forb-grass meadows and willow and alder thickets cover the majority of these islands. Some alpine tundra exists at higher elevations. Snow blankets these islands during the winter from lows sweeping eastward along the Aleutians. These islands are entirely free of permafrost.

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World Wide Web Links

Forest insect and disease survey information and general forest health information:

<http://www.fs.fed.us/r10/spf/fhp>

USDA Forest Service, State & Private Forestry, Forest Health Protection site for Alaska with information on Alaskan insects and diseases, bibliography listing, and links to other Forest Health sites. The section presents a program overview, personnel information, current forest insect and disease conditions throughout the state, forest insect and disease biology, control, impacts, Sbexpert software and other Forest Health issues. This Home Page is periodically updated and is a good source of information on Alaska Forest Health issues.

<http://www.dnr.state.ak.us/forestry/index.htm>

An Alaska Department of Natural Resources, Division of Forestry home page was assembled in late 1996 for the fire and resource management programs. The site is currently under development but information is available on several of Forestry's programs, including forest health and forest insect surveys. Information will be updated as personnel and funding permit. Users may check the site for information relating to forest health. A link is provided on the home page for accessing forest health and insect survey information and to send an e-mail message. The URL for this insect and disease link is **<http://www.dnr.state.ak.us/forestry/insects.htm>**.

<http://www.asgdc.state.ak.us>

This is the State of Alaska, Department of Natural Resources' Geographic Data Clearinghouse site that is directly patterned and linked to the AGDC site maintained at the U. S. Geological Survey, EROS (Earth Resource Observation Satellite) field office in Anchorage—SEE AGDC link below. The State of Alaska-maintained section of this site contains data layers information in the form of metadata, or "data about the data", that describe the content, quality, condition, and other characteristics of the data. The metadata is compliant with federal geographic data committee (FGDC) standards. For example, data on land status, transportation, physical boundaries—such as coastline, conservation units, etc., and links to state resource information (e.g., forest pest damage surveys, Exxon Valdez restoration data, CIIMMS) and links to other agency forest pest and forest health information and data can be found here. The site is not complete since statewide participation for data submission and access links does not exist at this time, however, the goal is to make this a clearinghouse node for state and local agencies. One example of a clearinghouse node, which does presently exist for data about the Kenai Peninsula that has fairly complete agency participation, is the CIIMMS (Cook Inlet Information Management & Monitoring System) site that can be found at **<http://info.dec.state.ak.us/ciimms>**

<http://agdc.usgs.gov>

The Alaska Geospatial Data Clearinghouse is a component of the National Spatial Data Infrastructure (NSDI). The Clearinghouse provides a pathway to find geospatial referenced data and associated metadata. The site is a link to data available from a multiple of federal, state and local agencies. The site is currently administered at the U.S. Geological Survey, EROS field office in Anchorage. From this website the Forest Health Monitoring Clearinghouse can be reached.

<http://agdc.usgs.gov/data/projects/fhm>

The Forest Health Monitoring Clearinghouse provides special resource databases of forest health related information to land managers, scientists, and the general public. Fourteen statewide data layers are available for downloading, including Vegetation/land cover, ECOMAP and Ecoregions, Wetlands Inventory, Timber Harvest and other disturbances, Yearly Insect and Disease Damage, Fire History, Fire Protection Zones, Fire Management Boundaries, Fire Fuels Models, Land Status/Ownership, Elevation, Hydrography, Soils, and Permafrost.

<http://www.fs.fed.us/r6/nr/fid/wid.shtml>

This site contains a valuable online catalog of information on Western Forest Insects and Diseases located on the USDA Forest Service Oregon/Washington Home-page. For specific information on the Spruce Beetle, the online version of the Forest Insect & Disease Leaflet #127 on the Spruce Beetle can be found at **www.na.fs.fed.us/spfo/pubs/fidls/sprucebeetle/sprucebeetle.htm**. This publication has been recently revised

nationally by the U.S. Forest Service and is available in brochure form.

<http://www.invasivespecies.gov/geog/state/ak.shtml>

The State of Alaska's web site for the National Biological Information on invasive species. Includes databases on invasive plants and a list of regulated noxious weeds.

Information Available From Statewide Aerial Surveys

Each year, forest damage surveys are conducted over approximately 30 million acres. This annual survey is a cooperative effort between USDA Forest Service, State and Private Forestry, Forest Health Protection (S&PF/FHP) and State of Alaska, Department of Natural Resources, Division of Forestry (AKDNR/DOF) forest health staffs to assess general forest conditions on Alaska's 129 million acres of forested area. About 25 percent of Alaska's forested area is covered each summer using fixed-wing aircraft and trained observers to prepare a set of sketch-maps depicting the extent (polygons) of various types of forest damage including recent bark beetle mortality, various hardwood and conifer defoliation, and abiotic damage such as yellow-cedar decline. A number of other damage types are noted including flooding, wind damage, and landslide areas during the survey. The extent of many significant forest tree diseases, such as stem and root decays, are not estimated from aerial surveys since this damage is not visible from aerial surveys as compared to the pronounced red topped crowns of bark beetle-killed trees.

Forest damage information has traditionally been sketched on 1:250,000 scale USGS quadrangle maps at a relatively small scale. For example, at this scale one inch would equal approximately 4 miles distance on the ground. When cooperators request specialized surveys, larger scale maps are sometimes used for specific areas to provide more detailed assessments. A digital sketch mapping system, augmented with paper maps, was used for the 2001 survey. This system displays the sketch mappers location via GPS input and allows the observer to zoom to various display scales. The many advantages of using the digital sketch map system include more accurate and resolute damage polygon placement and a shorter turnaround time for processing and reporting data.

Due to the short Alaska summers, long distances required, high airplane rental costs, and the short time frame when the common pest damage signs and tree symptoms are most evident (i.e., usually only during July and August), sketch mappers must strike a balance to efficiently cover the highest priority areas with available personnel schedules and funding.

Prior to the annual statewide forest conditions survey, letters are sent to various state and federal agency and other landowner partners for survey nominations. The federal and state biological technicians and entomologists decide which areas are the highest priority from the nominations. In addition, areas are selected where several years' data are collected to establish trends from the year-to-year mapping efforts. In this way, general damage trend information is assembled for the most significant pests and compiled in this annual Conditions Report. The sketch map information is digitized and put into a computerized Geographic Information System (GIS) for more permanent storage and retrieval by users.

Information listed in this Appendix is a sample of the types of products that can be prepared from the statewide surveys and GIS databases that are available. Due to the relatively high cost of mass-producing hard copy materials from the survey data, including colored maps, a number of other map products that are available have not been included with this report. In addition, maps which show the general extent of forest insect damage from 2000 and previous statewide aerial surveys, landowner boundaries, and other types of map and digital data can be made available in various formats depending on the resources available to the user:

Submit data and map information requests to:

Roger Burnside, Entomologist
State of Alaska Department of Natural Resources
Division of Forestry Central Office
Resource Section-Forest Health
550 W. 7th Avenue, Suite 1450
Anchorage, AK 99501-3566
Phone: (907) 269-8460
Fax: (907) 269-8902
E-mail: roger_burnside@dnr.state.ak.us

Kathy Matthews, Biotechnician
USDA Forest Service,
State and Private Forestry, Forest Health Protection
3301 C Street, Suite 522
Anchorage, AK 99503-3956
Phone: (907) 743-9465
Fax: (907) 743-9479
E-mail: kmatthews03@fs.fed.us

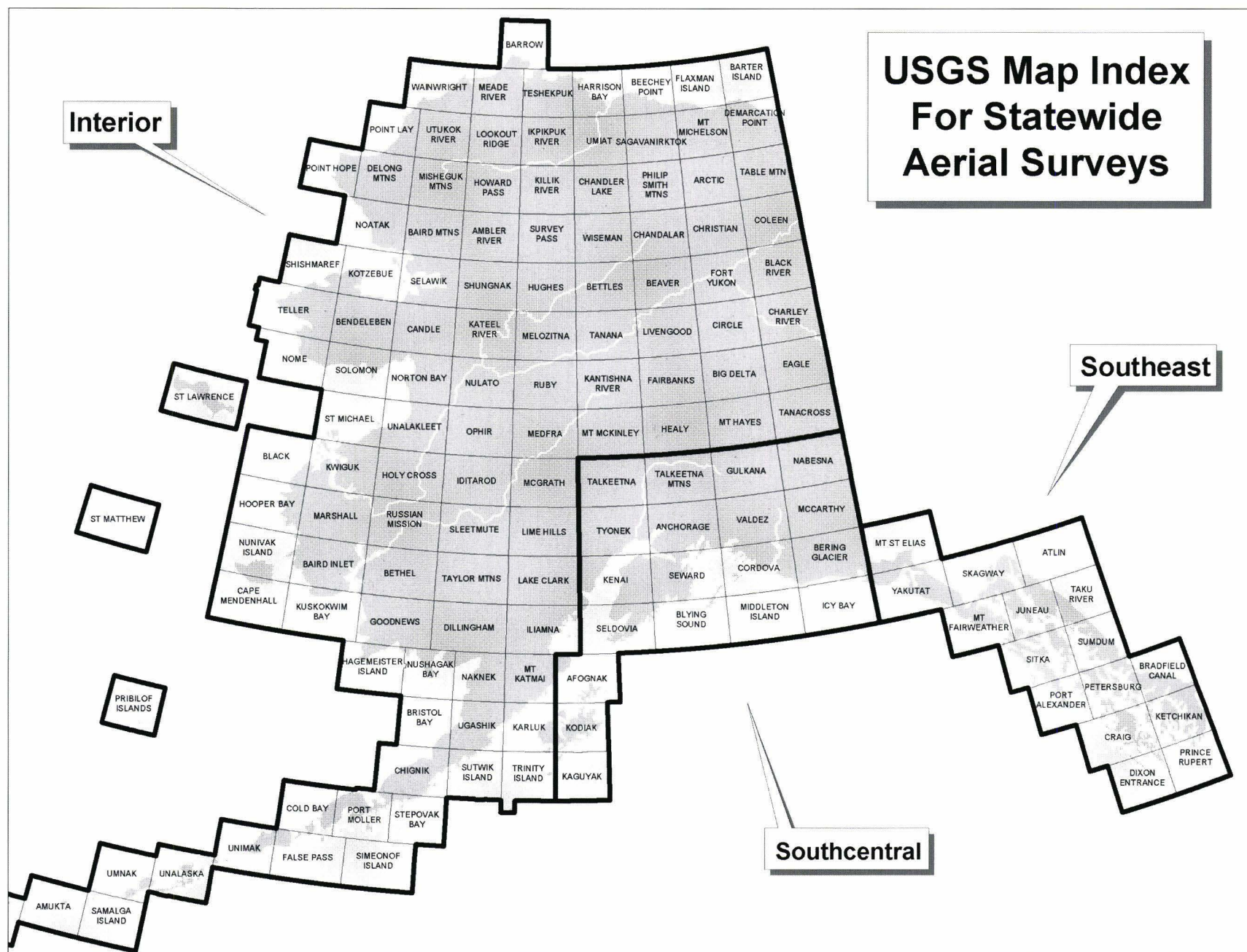
Map information included in this report: “Forest Insect And Disease Conditions In Alaska -2001”

- ♦ **Aerial Detection Survey, Significant Pest Activity**, 11x17 in. format, depicting spruce beetle, black-headed budworm, spruce budworm, spruce aphid, larch sawfly, and spruce needle rust (color; showing enhanced representation of damage areas).
- ♦ **2001 Alaska Forest Damage Surveys Flight Lines and Major Alaska Landownership Blocks** (includes table listing acres surveyed by landowner based on flight lines flown for the 2001 aerial surveys).
- ♦ **Kenai Peninsula Region Spruce Beetle Activity 1996-2001**, 8 ½ x 11 in. format, depicting sequential year-by-year spruce beetle activity in south-central Alaska, including the Kenai Peninsula, Cook Inlet area to Anchorage & Talkeetna (includes vegetation base layer).
- ♦ **A Decade of Spruce Beetles: Year 2001**, 8 ½ x 11 in. format, depicting 2001 damage in red and prior damage, 1990-2000 in yellow (includes color shaded relief base showing extent of forest landscape and sample photos of spruce beetle impact).
- ♦ **Southeast Alaska Cedar Decline 2001 Aerial Detection Surveys**, 8 ½ x 11 in. format, depicting cumulative Alaska yellow-cedar decline over several years (includes a sample photo of cedar decline. Forested areas are delineated with color shaded relief background)
- ♦ **Spruce Aphid Defoliation**, 8 ½ x 11 in. format, depicting defoliation in southeast Alaska over recent years with detailed insets of three southeast Alaska communities (includes color shaded relief base showing extent of the forest landscape).

[Map data for maps provided by USFS/S&PF and AKDNR, Anchorage; cedar decline data provided by USFS/S&PF, Juneau]

Map and GIS Products Available Upon Request:

- ♦ Digital data file of 2001 forest damage coverage in ArcInfo cover or ArcView shapefile(ESRI, Inc.) format. GIS data files are available at the following URL: <http://agdc.usgs.gov/data/projects/fhm/>.
- ♦ An electronic version of this report, including maps and images, will be available at the Alaska USFS, State & Private Forestry, Forest Health Protection web site (URL: <http://www.fs.fed.us/r10/spf/fhp>)
- ♦ Cumulative forest damage or specific-purpose damage maps prepared from AK/DOF or AK USFS, S&PF, FHP geographic information system database.
- ♦ Forest Insect & Disease Conditions in Alaska CD-ROM (includes most of digital forest damage coverages in the AKDNR/DOF database in viewable formats and a copy of the 2001 Alaska Forest Insect & Disease Conditions Report in .pdf format; a fee may be assessed depending on availability of copies and amount of data required for the project).



Quadrangle Areas Flown During 2001 Statewide Aerial Surveys:

*Quads without insect damage reported for 2001 are marked with an asterisk.

South-central Alaska

Anchorage	Nabesna
Bering Glacier	Seldovia
Blying Sound*	Seward
Cordova	Talkeetna
Gulkana	Talkeetna Mountains
Icy Bay	Tyonek
Kenai	Valdez
McCarthy	

Southeast Alaska

Bradfield Canal	Port Alexander
Craig	Prince Rupert*
Dixon Entrance	Sitka
Juneau	Skagway
Ketchikan	Sumdum
Mt. Fairweather	Taku River
Mt. St. Elias*	Yakutat
Petersburg	

Interior Alaska

Beaver	Lake Clark
Bethel	Lime Hills*
Bettles *	Livengood
Big Delta	McGrath
Black River	Medfra*
Charley River	Melozitna
Christian	Mt. Hayes
Circle	Mt. McKinley
Coleen	Naknek*
Dillingham	Nushagak Bay*
Eagle*	Nulato
Fairbanks	Ophir
Fort Yukon	Ruby
Goodnews	Russian Mission
Healy*	Shungnak*
Holy Cross	Sleetmute
Hughes *	Tanacross
Iditarod	Tanana
Iliamna	Taylor Mountains*
Kantishna River	Unalakleet
Kateel River	

Tree damage codes used in 1989-2001 aerial surveys and GIS map products.

*The codes used for 2001 aerial surveys and GIS maps are marked with an asterisk.

ALB	Aspen leaf blight	HSF*	Hemlock sawfly
ALD	Alder defoliation	HTB	Hardwood top breakage
ALM	Aspen Leaf Miner	HWD	Hardwood defoliation
ALR*	Alder leafroller	IPB	IPS and SPB
ASD*	Aspen defoliation	IPS*	Ips engraver beetle
ASF*	Alder sawfly	LAB	Larch beetle
BAP	Birch aphid	LAS*	Larch sawfly
BHB*	Black-headed budworm	LAT*	Large aspen tortrix
BHS	BHB/HSF	OUT	Out (island of no damage)
BID*	Birch defoliation	POD*	Porcupine damage
BLM	Birch Leaf Miner	SBM	Spruce/Larch budmoth
BLR	Birch leaf roller	SBR*	Spruce broom rust
BSB	BHB/SPB	SBW*	Spruce budworm
CDL*	Cedar decline	SLD*	Landslide/Avalanche
CLB*	Cottonwood leaf beetle	SMB	Spear-marked black moth
CLM	Cottonwood leaf miner	SNA*	Spruce needle aphid
COD*	Conifer defoliation	SNR*	Spruce needle rust
CTB	Conifer top breakage	SPA	Spruce aphid
CWD*	Cottonwood defoliation	SPB*	Spruce beetle
CWW	CWD and WID	SPC	SPB and CLB
FIR*	Fire damage*	WID*	Willow defoliation
FLO*	Flooding/high-water damage	WIR	Willow Rust
FRB*	Sub Alpine Fur Beetle	WLM*	Willow Leafblotch Miner
HCK*	Hemlock canker	WNT	Winter damage
HLO	Hemlock looper	WTH*	Windthrow/Blowdown

Note: In the digital data all insect and disease activity has an intensity attribute. Agents typically resulting in defoliation or discoloration are attributed with a High, Medium or Low. Agents typically resulting in mortality are attributed with a tree per acre estimate. Digital data and metadata can be found at the following URLs:

<http://agdc.usgs.gov/data/projects/fhm/>

or

<http://www.fs.fed.us/r10/spf/fhp>

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